

Patterns of Several Heavy Metals Accumulation across Age and Gender Group

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Annotation: Some metals are considered non-essential for biological processes, such as zinc (Zn), the metal lead (Pb), the metal mercury (Hg), the arsenic (As), the nickel (Ni), and cadmium (Cd)., Conversely, elements such as molybdenum, manganese, copper, iron, and zinc are vital in minute amounts. Any hazardous metal can be classified as a heavy metal, regardless of its atomic weight or density. Seventy-five samples from both gender were included in the present study with age range (15_70 years). 50 patients with blood diseases were selected from Teaching Al-Diwaniyah Hospital; and 25 participant apparently healthy control group. Heavy metals parameters measurement was performed on blood serum by use (Atomic absorption spectrophotometer), model Buck Scientific - 210VGP Atomic Absorption Spectrophotometer. The blood serum, were digestion to examine the heavy elements of the total study sample (treatment and control).The results showed that females represented 52% of the sample, while males accounted for 48%, indicating a balanced gender distribution. The most represented age group was 26–37 years (22.67%),

highlighting a focus on generally active age groups. Data analysis revealed statistically significant effects of gender and age on the amounts of certain minerals in bloodstreams, like lead, also known as Pb, as well as aluminium (Al), with p-values < 0.05 indicating statistical significance. For instance, lead levels were seen to be elevated in males relative to females. This highlights the need to consider environmental factors that affect health. This study seeks to examine the influence of gender, age, on the concentration of metals in the blood.

Keywords: heavy metals, healthy human, blood serum.

1. Introduction

Metals that are heavy are substances that, despite their rarity in nature, pose significant risks to ecosystems, wildlife, and the health of people. (Fu & Wang, 2011). The principal sources of heavy metal pollution are mobile sources, such as vehicles, and sources that are fixed, including industries, residential structures, and power plants. (He et al., 2005). The functions and chemical properties among the diverse category of elements referred to as heavy metals vary significantly (Alloway, 2013). Heavy metals predominantly fall into the category of transition elements in the Periodic Table (Kabata-Pendias & Mukherjee, 2007). Elements possessing Substances with a specific weight above five g/cm³ frequently qualify as heavy metals. (Duffus, 2002). Metal pollutants do not possess a recognised homeostasis mechanism and are often non-biodegradable (Duffus, 2002; Khalef et al., 2022). They can influence living systems directly or indirectly merely by their presence on aquatic ecosystems (He et al., 2005; Khalef et al., 2022). Where levels of one or more heavy metals exceed normal levels, this is designated anthropogenic contamination of heavy metals in ancient mining locations (Fu & Wang, 2011; Khalef et al., 2022). Both humans and animal adversely affected by these metals that are heavy, which damage vital parts of the body. (Alvarez et al., 2023).

Heavy metal pollution inhibits the activity of metabolising enzymes, thereby obstructing the decay of chlorinated organic compounds, a distinct form of environmental contamination (Singh et al., 2024). Prior studies have demonstrated that heavy metals cannot be entirely eradicated from the environment, but they can be effectively neutralised or transformed into less harmful forms to mitigate their adverse impacts. (Kumar and Pratush, 2018). There are several sources of pollution, including mineral extraction waste from industries, surface water from cities, waste water discharge, the erosion of soil, being weathered of the Earth's crust, insecticides, and chemicals that control agricultural diseases. metallic water pipes, traffic emissions, and combustion byproducts from Coal-fired power stations contribute to the formation of metals that are heavy in the biosphere, encompassing rocks, soils, and water. (Macklin et al., 2023). Metals that are heavy are known to be harmful to the environment because they are poisonous, stay in atmospheres for a long time, and can build up in the bodies of people. Metals that are heavy that are poisonous to

land and water ecosystems are an important concern for the environment that also affects health. Several metals are naturally present, but others are created by human activities. Metals that are heavy in mass are elements that have a high atomic mass and are poisonous to living things. Numerous harmful metals can be fatal to people as they pollute the environment and the atmosphere. Individuals together with other organisms may encounter metals that are heavy through their intake of food, which can become highly perilous when they combine it with in elements in the environment such as the air, water, and soil (Mitra *et al.*, 2022; Science Direct, 2023). The main way that heavy metals are hazardous is by making reactive species of oxygen, which cause damage through oxidation and have negative health effects. (Zhang *et al.*, 2024). Using water that has metals that are heavy in it is connected to an elevated incidence of illness as well as mortality around the world. (Rehmn *et al.*, 2018). While acute poisoning is caused by inhaling or coming into contact with dust, fumes, or vapors at work or by using some therapeutic procedures improperly, Metals that are heavy can get into the human body all the time via nourishment, air, water, or dermal absorption. (Lentini *et al.*, 2017). The most frequent way that youngsters are exposed is via accident (Patel *et al.*, 2024). Heavy metal poisoning may affect the brain, bloodstream, lung function, the renal system, liver function. In addition, other organs of the body (Lentini *et al.*, 2017).

1.2 Some of heavy metals

1.2.1 Lead (Pb):

Lead, a prevalent heavy metal, adversely affects the heart, kidneys, of reproductive, bones, neural, and hematopoietic systems. It also contaminates our surroundings and builds up in the body of people through being absorbed, bio availability, biologic concentration, and biological magnification. Due to its distinctive chemical as well as physical characteristics, lead is ideal for various applications. It is typically related to activity by humans and is harmful to health. The current article review examines the impact of lead exposure on individuals' long-term health. Poisoning with lead may result in harm on the kidneys, brain, reproductive organs, and central nervous system Collin *et al.*, (2022). The article also emphasises concerns related to increasing levels of lead in the blood in both pregnant women and males. Lead is one of the most toxic substances in the periodic table of elements. It is stored in bone, mimics the characteristics of calcium, and disrupts metabolic processes throughout the whole life cycle. Lead enhances the risk of heart disease, kidney damage, as well as premature mortality in humans., while diminishing IQ levels. "One of the great environmental achievements of all time is the elimination of lead from gasoline," stated Carol Browner, a former administrator of the US Environmental Protection Agency (EPA) (Luby, 2024).

1.2.2 Cadmium:

Cadmium, also referred to as CD, is a malleable metal that manifests as a bluish or white with a silver a fine powder. It occurs naturally within minerals, water, and soil. Approximately 0.2 mg per kilogramme. Cadmium is classified as a stimulating, carcinogenic, and poisonous element. Its the average biology half-lives in the body of an individual is between sixteen to thirty years. Slow poisoning is thought to be linked to hypertension and specific respiratory disorders, such as bronchitis, asthma, and emphysema. The years of age as well as health condition of the individuals exposure, the kind of diet, and the period of exposure can all influence the symptoms of cadmium poisoning. Diet is the only source of exposure for people who don't smoke and don't work with it. Natural events like erupting volcano and things happening on their own burning of biomass can produce atmospheric Cd. Although Cd is naturally present on Earth, no biological role in higher species has been discovered for it, Its toxicity is well-documented and has been the subject of several investigations. (Peana *et al.*, 2022).

1.2.3 Aluminum (Al):

Aluminium is the thirteenth element in the periodic table and constitutes 8.2% by weight of the

Earth's crust, making it the third most abundant element. Aluminium possesses a comparatively low density and a silvery lustre. It has multiple industrial applications in chemical and food processing, pharmaceuticals, and construction (Brough and Jouhara 2020). The brain is arguably the most significant target of aluminium poisoning. Aluminium is gradually excreted from the human body, with a half-life of approximately seven years; hence, prolonged cumulative injury to neurones may result in significant clinical effects (Drago et al. 2008). Experimental study suggests that aluminium compounds may exhibit neurotoxicity due to their potential to generate harmful reactive oxygen species (ROS), which could affect several organelles, including nuclei, lysosomes, and mitochondria (Pasha and Oglu 2017; Wu et al. 2012). Aluminum-induced oxidative stress in mitochondria leads to a reduction in mitochondrial membrane potential, crucial for the proper functioning of brain cells (Rahimzadeh et al. 2022). The pathogenesis of neurodegenerative illnesses, including Alzheimer's disease, and its correlation with Al³⁺ toxicity have been documented (de Sautu et al. 2018).

2. Material and method

2.1 Study design.

Seventy five samples from both gender were included in the present study with age range (15_70 years). 50 patients with blood diseases were selected from Teaching Al-Diwaniyah Hospital ; and 25 participant apparently healthy control group. The study samples were collected in the period from October 2024 to Janury 2025.

2.2 Sample collection.

The blood serum, were digestion to examine the heavy elements of the total study sample (treatment and control) included: One millilitre of blood serum was placed in a test tube, to which one millilitre of strong nitric acid was added and allowed to stand for 24 hours. Nitric acid concentrate and the peroxide of hydrogen are combined in a 1:2 ratio at an approximate temperature of 70 °C and allowed to react for up to two hours, until the solution clarifies. The samples were subsequently diluted with deionised water to a volume of 10 ml and filtered using a 0.45 µm pore filter paper.

2.3 Determination of heavy metal.

Using the 210 VGP Atomic Absorption Spectrophotometer (AAS), we looked at heavy metals like the metal zinc (Zn), the metal copper (Cu), the metal lead (Pb), the cadmium (Cd), and the element nickel (Ni). The atomic absorption apparatus looks at heavy metals like cadmium, lead, Nickel, the elements copper, and The element zinc, Based on the principle of flame atomic absorption , One of the analytical criteria for this apparatus is the existence of standard solutions, which contain these components in a quantities known to ascertain the percent of the sample., as each mineral has a light source . AAS technology relies on the principle that substances like minerals absorb light at wavelengths that are specific facilitating the full breakdown of metal ions in solution through a laminar flame. Light of the suitable wavelength is supplied, and the quantity of absorbed light is quantified in comparison to the standard the curve. (Walker et.al.,2016).

Utilising an open- flame absorption atomic apparatus, the models were removed from the freezer and allowed to equilibrate to a laboratory room temperature of 25°C. Subsequently, 0.5 ml was extracted from the sample and transferred to a volumetric vial. 1 ml of concentrated 70% HNO₃ were added, and the mixture was incubated in a water bath at 40°C for 30 minutes (Florez et al., 2016). Subsequently, the solution was transferred to the designated container, and the volume was adjusted to the mark. The concentration of the compounds in the blood samples was quantified using an AAS instrument.

2.4 Heavy metals analysis:

Heavy metals parameters measurement was performed on blood serum by use (Atomic absorption spectrophotometer), model Buck Scientific - 210VGP Atomic Absorption Spectrophotometer.The

blood serum, were digested to examine the heavy elements of the total study sample (treatment and control) included: One millilitre of blood serum was placed in a test tube, to which one millilitre of strong nitric acid was put in and allowed to stand for 24 hours. Nitric acid that is concentrated and peroxide of hydrogen are combined in a 1:2 ratio at a temperature of 70 °C and allowed to react for up to two hours, until the resulting solution clarifies. Then the samples were diluted with deionized water to 10 ml, and filtration with 0.45 μ pore filter paper. Subsequently, samples that had been digested were analysed using an atomic absorption spectrometer to determine the concentration of heavy metals.

2.5 Statistical analysis:

The statistical program (SPSS Ver.25) was used in the statistical examination of the results of the current study under the level of significance (0.05) and the test of least significant difference (LSD) Least Significant Difference (Al-Rawi, , 2002), as well as according to the correlation coefficient between physical and chemical variables . While heavy metals were analyzed using a complete random design Complete Randomize Design (CRD) and averages were tested using (Duncan Test) multiple range depending on the method mentioned in Al-Rawi (2002), the results were assessed at a significant level ($p < 0.05$).

3. Result

3.1 Distribution of study sample by gender

The findings of the current study indicated that 48% of study samples was male, while there was 52 % of female, figure (3-1).

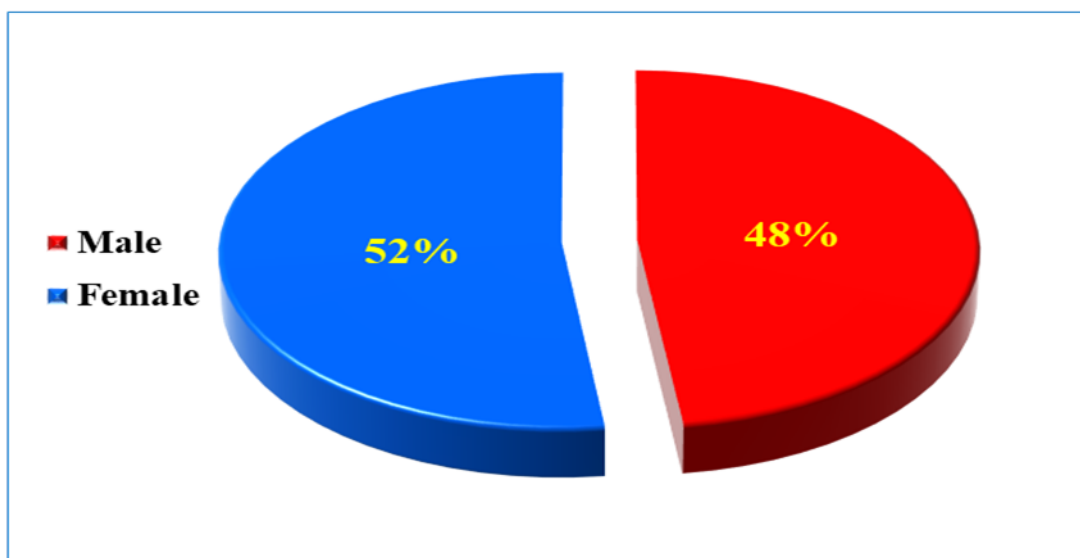


Figure (3.1): Distribution of study sample by gender.

3.2 Sex impact on the concentration of heavy metals in the blood .

The results of the current investigation indicated substantial variations in blood Pb levels within males and females (significance level < 0.05). Moreover, there were notable disparities between males and females regarding the concentration of Aluminium in the blood (p -value < 0.05). table (3.1).

Table (3.1) Sex impact on the concentration of heavy metals in the blood

Gender Metals	Male (n=43) Mean \pm S.D.	Female (n=42) Mean \pm S.D.	T-Value	Sig.
Pb	0.0023 \pm 0.0017	0.0041 \pm 0.0041	2.468	0.017*
Cd	0.2452 \pm 0.0511	0.2424 \pm 0.0364	0.274	0.785

Zn	0.0811±0.0755	0.1162±0.1080	1.641	0.105
Cu	0.4119±0.2270	0.4668±0.3691	0.767	0.445
Al	0.0087±0.0243	0.0717±0.1685	2.310	0.026*
S.D. = Standard Deviation				
* The differences are significant at the 0.05 level.				

The significant differences may be due to The health effects of heavy metal' exposure differ by gender. These discrepancies may be explained by the impact of gender-related hormones, including the cardio protective role of estrogen and the adverse effect of male testosterone on the cardiovascular system. The specific underlying mechanisms are still unknown, though. (kim *etal* .,2024).Considering possible differences based on sex.(Ge *etal* .,2021).

Exposure to environmental heavy metals, including the heavy metals lead and the metal mercury, might alter midlife. women's circulating levels of SHBG, FSH, and E2. and they experienced the menopausal transition as they grew older. Lower serum E2 levels were linked to higher amounts of mercury as well as lead in the urine. Serum Follicle-Stimulating Hormone levels were positively correlated with greater lead concentrations. Cadmium concentration and serum SHBG levels were positively correlated. (Wang *etal* .,2023).

that there is a sex difference in the concentration levels of a heavy metal amalgamation. (Duan *etal* .,2020).

3.3 Distribution of study sample by age.

The findings of the current study indicated that the age demographic (2-13 years) was 16%, (14-25 years) was 20%, (26-37 years) was 22.6%, (38-49 years) was 33%, (50-61 years) was 12%, (62-73 years) was 67.7% and the age group (74-85 years) was 5.33%, Figure (3-2).

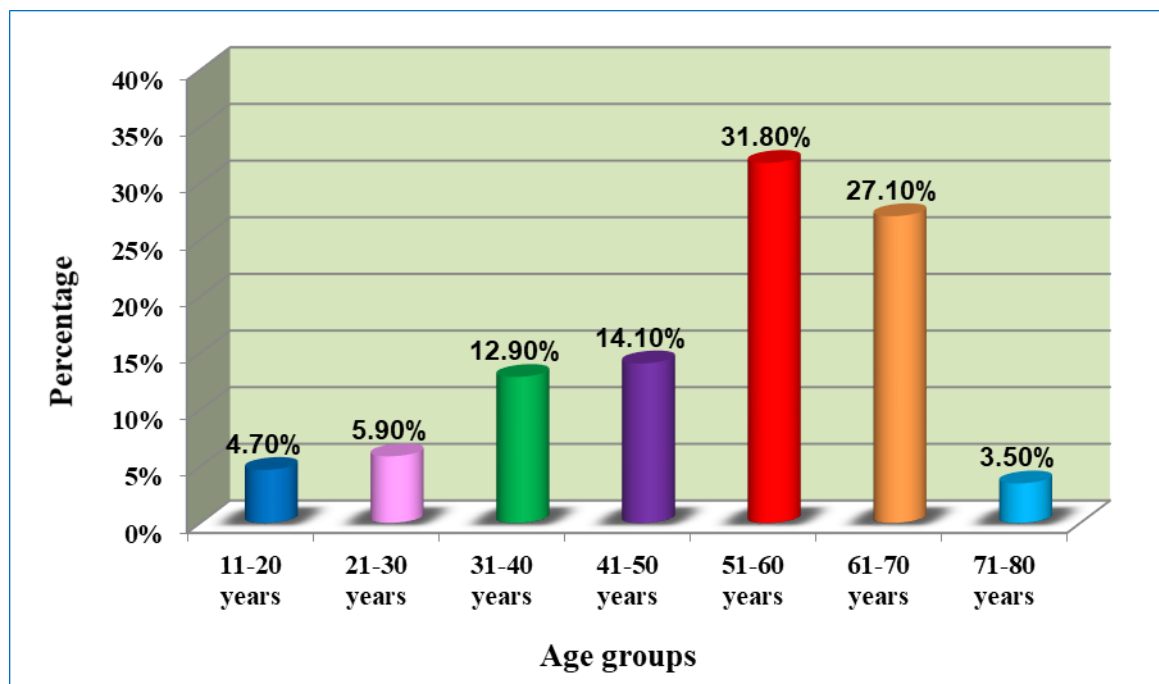


Figure (3-2): Distribution of study samples by age.

3.4 Impact of age on the concentration of heavy metals in the blood

The present study showed significant differences between age groups for both Pb and Cd ($p < 0.001$, $p < 0.01$) correspondingly. The significant differences may be due to Toxic metals were discovered to have more detrimental effects on the centenarians' aging, including diabetes and chronic kidney disease. Exposure to dangerous metals can adversely affect the health of individuals. and harm several organs. Centenarians who have had Individuals with less exposure

to harmful metal contamination are likely to have experienced increased longevity. (Wei *etal.*,2021)

Immune function is negatively impacted by metal exposure. Immunosuppression caused by exposure to lead, cadmium, arsenic, and mercury decreased the total lymphocyte count in paediatric populations, namely T cells and their subsets being particularly affected. Exposure to Pb and Cd is linked to higher innate immune cell counts (Zheng et al .,2023).The results of present study in agreement with.(Kothapolli, 2021).

Table (3.2) Impact of age on the concentration of heavy metals in the blood

Metals Age	Pb Mean±S.D.	Cd Mean±S.D.	Zn Mean±S.D.	Cu Mean±S.D.	Al Mean±S.D.
11-20 years (n=12)	0.0073 ^a ±0.00 55	0.2395 ^{ab} ±0.04 41	0.0704 ^a ±0.04 78	0.4404 ^a ±0.27 48	0.0016 ^a ±0.00 06
21-30 years (n=15)	0.0038 ^b ±0.00 24	0.2206 ^a ±0.01 71	0.1308 ^a ±0.12 12	0.3841 ^a ±0.13 03	0.0190 ^a ±0.03 58
31-40 years (n=17)	0.0015 ^b ±0.00 05	0.2409 ^{ab} ±0.04 48	0.1312 ^a ±0.12 69	0.4686 ^a ±0.45 64	0.0951 ^a ±0.20 72
41-50 years (n=13)	0.0033 ^b ±0.00 20	0.2796 ^b ±0.05 68	0.0508 ^a ±0.01 78	0.3077 ^a ±0.13 64	0.0015 ^a ±0.00 05
51-60 years (n=9)	0.0014 ^b ±0.00 08	0.2402 ^{ab} ±0.03 20	0.1007 ^a ±0.10 52	0.5265 ^a ±0.44 67	0.1285 ^a ±0.19 04
61-70 years (n=5)	0.0017 ^b ±0.00 08	0.2236 ^a ±0.01 60	0.0725 ^a ±0.01 54	0.6273 ^a ±0.18 81	0.0013 ^a ±0.00 02
71-80 years (n=4)	0.0025 ^b ±0.00 19	0.2720 ^b ±0.04 43	0.1206 ^a ±0.04 38	0.5369 ^a ±0.18 74	0.0012 ^a ±0.00 02
P-Value	<0.001**	0.01**	0.189	0.435	0.072
S.D. = Standard Deviation					
Averages that share the same alphabet are not significantly difference between them according to the Duncan test.					
** The differences are significant at the 0.01 level.					

4. Conclusions:

There are significant differences between males and females in the concentration of lead (Pb) and aluminum (Al) in the blood. These differences may be attributed to biological and hormonal variations, such as the protective role of estrogen versus the detrimental effect of testosterone on cardiovascular health. Significant differences were observed in lead and cadmium (Cd) levels among different age groups. The study suggests that exposure to toxic metals becomes more harmful with age, contributing to chronic conditions like diabetes and kidney disease.

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