Asian Hematology Research Journal

Volume 7, Issue 1, Page 23-30, 2023; Article no.AHRJ.95332

Assessment of Essential Trace Elements and Toxic Metal Contaminants of Banked Blood Designated for Transfusion in Igbinedion University Teaching Hospital, Okada, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95332

Original Research Article

Received: 25/10/2022
Accepted: 28/12/2022
Published: 19/01/2023

ABSTRACT

Blood transfusion is a critical part of patient's intensive care and is life saving for patients with severe anemia or hemorrhage. The goal of blood banking is to provide adequate and safe blood to recipients at no risk to donors. These donors may have had a variety of exposures to substances including toxic heavy metals from environmental and occupational sources. Exposure to

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environmental heavy metals is common among Africans. Although many of these metals are known neurotoxicants, to date, monitoring of this exposure is limited, even in countries such as Nigeria that are undergoing rapid industrialization. Concentration of Lead, Cadmium, Zinc and copper in samples from eighty six (86) blood donors comprising of O, A, B and AB blood groups were estimated by inductively Coupled Plasma Mass Spectrometer (ICP-MS), aliquot of 20µL of blood sample was aspirated into the quartz spray chamber after instrument was standardized with standard blank and various standards (Cadmium, Lead, Zinc and Copper). Data values of Lead, Cadmium, Zinc and Copper obtained indicated that essential and toxic metal levels from donor blood were within permissible range. Data were analysed using SPSS version 20 and significance level were set at p =≤ 0.05. The observed blood levels of cadmium and lead in donor blood banked designated for transfusion in this study were in correlation with the permissible range of toxic metals. More so, there was an insignificant increase in the essential metals level in the blood donor group when compared with the reference range. This study therefore concludes that donor blood designated for transfusion at Igbinedion university teaching hospital Okada had metal concentrations that is within the estimated tolerable concentration.

Keywords: Blood transfusion; heavy metals.

1. INTRODUCTION

“Blood donors are grouped into voluntary donors, replacement donors, and paid donors. The safest of these is the voluntary donor blood. Blood banking is highly regulated to ensure both donor and recipient safety. The goal of blood banking is to provide adequate and safe blood to recipients at no risk to donors” [1]. “Baseline hemoglobin of 12 g/dl and 13 g/dl for potential female and male donors' respectively, and a donation interval of 12 weeks minimum have been stipulated in some countries to ensure donor safety” [2,3]. “The World Health Organization (WHO) has established a target of obtaining 100% voluntary non- remunerated donation by 2020 as a means of achieving this goal, and voluntary non-remunerated blood donation is promoted in Nigeria, a member of WHO has not made much success in attracting voluntary donors” [4]. Only 5% of donor blood used in Nigeria is donated voluntarily; the majority of donor blood is still obtained from voluntary donors; family replacements and paid donors [1,5].

However these donors could have been exposed to a range of toxins, including hazardous heavy metals through the environment and their jobs [6]. Africans frequently experience environmental heavy metals exposure. Even in nations like Nigeria, which are rapidly industrializing, monitoring of this exposure is poor despite the fact that many of these metals are proven neurotoxicants. A crucial initial step in estimating the public health burden of metal exposure and directing its eradication is an assessment of the impact and potential causes of metal exposure.

“The federal government has codified exposure levels acceptable to adult workers and to children exposed to environmental contaminants. These exposures occur mainly via ingestion or inhalation. Toxic heavy metals present in transfused blood are administered intravenously. Safe levels for intravenous administration of most of these toxic metals are unknown. Toxic metals such as lead in donor blood have previously been shown to be present at concentrations that pose a health risk for infants” [7]. “Aluminum (Al), arsenic (As), beryllium (Be), cadmium (Cd), mercury (Hg), Lead (Pb), Manganese (Mn) and Nickel (Ni) have been studied extensively due to the known serious adverse health effects associated with human exposure to these metals. According to the Agency for Toxic Substance and Disease Registry’s (ATSDR) priority list of hazardous substances, the latent effects from these heavy metals include carcinogenesis, neurotoxicology and developmental deficits in humans and animals” [8-10]. “Toxic metals tend to stay in the body for long periods of time and may cause detrimental adverse effects on human growth and development” [11,12]. Therefore, it is an urgent and high priority to explore and determine the burden of exposure of toxic metals from human blood to the developing infants. It has been hypothesized that `metals, known to have especially detrimental neurotoxic health effects, could be present in banked blood designated for transfusion at potentially toxic concentrations. Thus this study aims at determining the levels of essential metals and toxic metals burden of banked blood designated for transfusion in Igbinedion University teaching hospital Okada.

2. MATERIALS AND METHODS

The study was carried out at the Analytical Laboratory of the International Institute for Tropical Agriculture (IITA), Ibadan, Oyo state and the department of Laboratory Medicine, Igbinedion University Teaching Hospital, Okada, Edo state, Nigeria.

2.1 Study Design

This cross-sectional study, individuals of different blood groups attend the Igbinedion University Teaching Hospital, Okada, Edo State as willing donors. After meeting the prerequisites for donation, the people gave their permission to take part. 86 people in all were recruited for this study.

2.2 Study Population

The study populations were made up of male and female individuals whose haemoglobin concentration were within the normal range as regards gender and were screened for transfusion and transmissible diseases.

2.3 Data Collection

Questionnaires were used to collect necessary information from the 86 voluntary donors which include socio-demographic data, frequency of blood donated, and other social habits such as smoking. The research instrument included data from laboratory investigation for transfusion and transmissible diseases

2.4 Specimen Collection

Aliquots of about 4ml of whole blood were collected from the blood bag serially numbered to tag with the 86 donor individuals into plain bottles, plasma samples were obtained after centrifugation and stored at -20℃ prior to analysis.

2.5 Specimen Analysis

Concentration of Lead, Cadmium, Zinc and copper in the sample were estimated by inductively Coupled Plasma Mass Spectrometer (ICP-MS) (Agilent 7500, Norwalk, U.S.A) adopting the methods of Fong et al. (2007).

The instrument was standardized with standard blank and various standards (Cadmium, Lead, Zinc and Copper). An aliquot of 20µL of plasma was aspirated into the quartz spray chamber. The concentration of the respective metal in the sample was displayed on the screen of the instrument after the run time was completed.

3. RESULTS

Table 1 shows the comparison of measured toxic metals and essential metals level in donor blood with permissible range. Data indicated that essential and toxic metal levels from donor blood were within permissible range.

Table 2 demonstrates the comparison of measured toxic metals and essential metals level in the donors' various blood groups. Data shows that blood group A, B, AB, and O donors' serum Lead concentrations do not differ significantly (P>0.05). Additionally, there were no differences between group A, B, AB, and O donors in the serum concentrations of cadmium, zinc and copper (P>0.05). Table 3 compares the levels of toxic metals and essential metals level in male donors and female donors. The mean blood contents of lead (P>0.05), cadmium (P>0.05), zinc (P>0.05), and copper (P>0.05) in male donors were not significantly different from those in female donors.

Table 4 shows the comparison of measured toxic metals and essential metals level in different age groups among blood donors. Data indicated an insignificant difference in the mean serum concentration of lead and cadmium (P>0.05) in the different age groups among blood donors. Furthermore there was no significant difference between the mean serum concentrations of Zinc and Copper (P>0.05) in the different age groups among blood donors.

Table1. Comparison of metals level in donor banked blood with reference ranges. (Mean ±SEM)

Measured toxic/essential metals	Donor banked blood	Reference range
Lead (µg/dl)	0.14±0.01	<10ug/dl
Cadmium (µg/dl)	0.07±0.01	0.03–0.12 µg/dl
Zinc (µg/dl)	78.46±1.09	70.46-177.53 µg/dL
Copper (µg/dl)	85.85±0.76	74.30-170.68 µg/dL

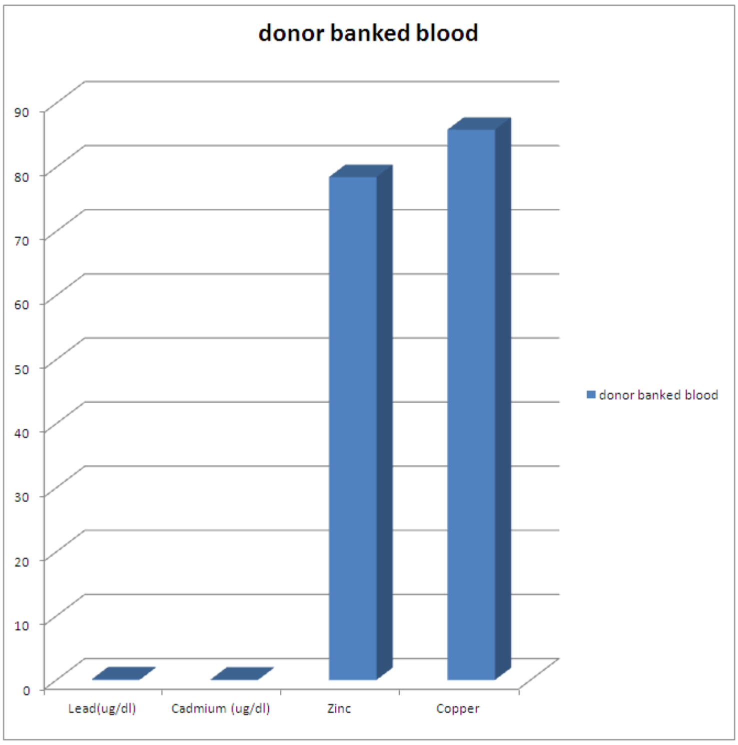

Fig. 1. Comparison of metals level in donor banked blood with reference ranges (Mean ±SEM)

Table 2. Comparison of metals level in different blood group among blood donors (Mean ±SEM)

Measured toxic and essential metals	Blood Group system				p-value
	A(n=9)	B(n=7)	AB (n=2)	O(n=68)	
Lead (µg/dl)	0.13±0.02	0.12±0.02	0.13±0.08	0.15±0.02	P>0.05
Cadmium (µg/dl)	0.07±0.01	0.06±0.02	0.09±0.01	0.06±0.01	P>0.05
Zinc (µg/dl)	79.14±2.92	84.19±3.01	86.00±0.32	88.60±1.27	P>0.05
Copper (µg/dl)	85.54±0.76	86.35±0.59	85.56±0.65	85.84±0.25	P>0.05

Note: SEM: Standard Error of Mean, P>0.05- Not Significant

Table 3. Comparison of measured toxic metals and essential metals level in male and female donors (Mean ±SEM)

Measured toxic and essential metals	Sex		p-value	Level of significance
	Male (n=76)	Female (n=10)		
Lead (µg/dl)	0.14±0.01	0.14±0.01	P>0.05	Not significant
Cadmium (µg/dl)	0.06±0.00	0.07±0.01	P>0.05	Not significant
Zinc (µg/dl)	79.46±1.09	76..90±2.66	P>0.05	Not significant
Copper (µg/dl)	85.82±0.21	85.85±0.61	P>0.05	Not significant

Note: SEM: Standard Error of Mean

Table 4. Comparison of measured toxic metals and essential metals level among the different age groups of blood donors (Mean ±SEM)

Measured toxic and essential metals	Age Group				p-value
	<21-25 (n=24)	26-30 (n=23)	31-35 (n=18)	36-40 (n=21)	
Lead (µg/dl)	0.12±0.01	0.16±0.03	0.12±0.01	0.17±0.03	P>0.05
Cadmium (µg/dl)	0.05±0.01	0.07±0.01	0.07±0.01	0.07±0.01	P>0.05
Zinc (µg/dl)	79.99±1.83	76.59±2.01	78.83±2.18	71.37±2.14	P>0.05
Copper (µg/dl)	85.95±0.35	85.32±0.35	85.66±046	86.39±0.20	P>0.05

Note: SEM: Standard Error of Mean

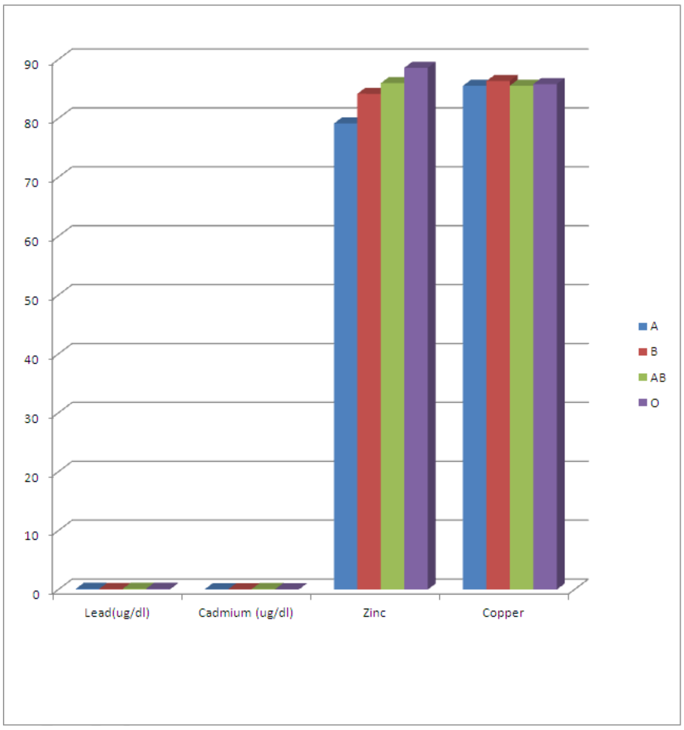

Fig. 2. Comparison of metals level in different blood group among blood donors (Mean ±SEM)

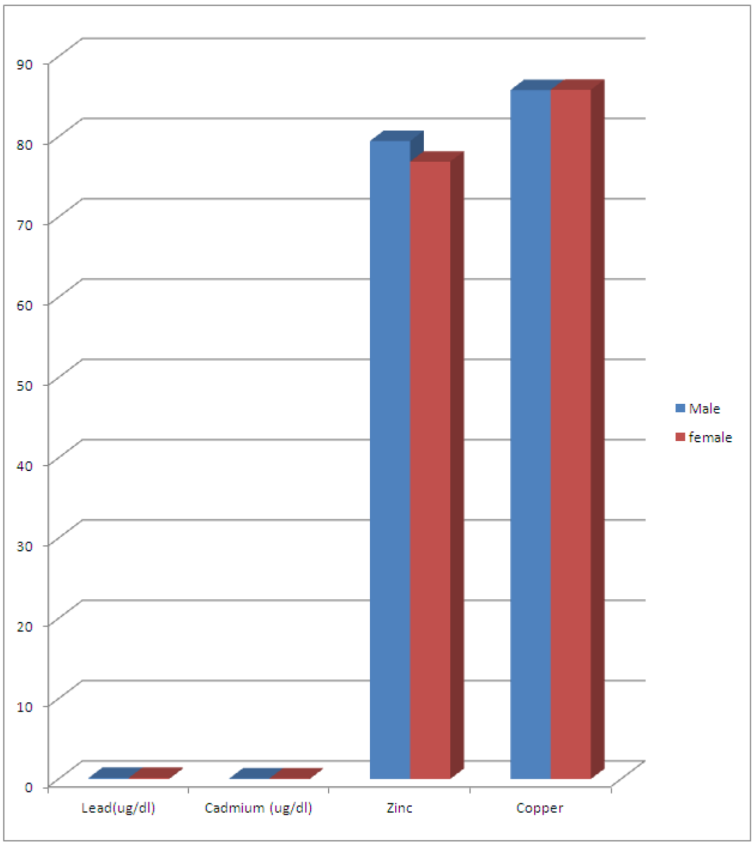

Fig. 3. Comparison of measured toxic metals and essential metals level in male and female donors (Mean ±SEM)

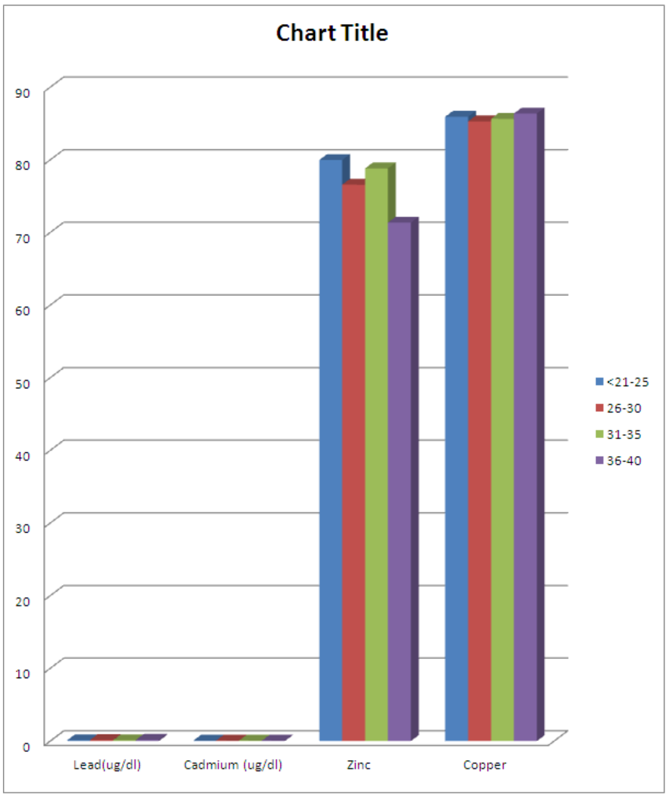

Fig. 4. Comparison of measured toxic metals and essential metals level among the different age groups of blood donors

4. DISCUSSION

Blood transfusion is a critical part of patient's intensive care and is life saving for patients with severe anemia or hemorrhage [13]. Furthermore, some heavy metals and trace elements are necessary for the continuation of human life and play an important role in various reactions in the human body (such as iron, selenium, copper, and zinc). However, the elements that are considered to be necessary for human metabolism may have toxic effect if the concentration in the blood exceed normal. On the other hand, some elements (such as lead, cadmium, arsenic and mercury) do not have a known role in human physiology and their accumulation in the body may pose a risk to health [14]. Therefore, the concentrations of heavy metals and trace elements taken from various sources must not exceed certain limits within the human body [15].

In this present study serum concentration of toxic metals and essential metals were determined in banked blood designated for transfusion in Igbinedion university teaching hospital. Data indicated an insignificant difference (P>0.05) in the serum concentration of lead and cadmium of the blood donors when compared with the permissible range according to WHO, (2019) 0.03–0.12 µg/dl for cadmium (Cd) and <10ug/dl for lead (Pb). The findings of this study were consistent with previous findings of Sundararajan et al. [16] who observed no significant difference in the toxic metal levels of banked blood designated for neonatal transfusion in USA when compared to mean blood concentrations from the 2013–2014 National Health and Nutrition Examination Survey (NHANES). The reason for this insignificant difference is not far-fetched as blood donors in Okada community are mainly made up of rural dwellers who may not have been exposed to sources of heavy metals such contaminated food , water and fumes from automobile exhaust. More so, research by Bearer et al. (2018) shows that heavy metal concentrations in donor blood are variable and can be greater in some regions that are highly industrialized and regions with heavy metal contaminated soil. Toxicities of heavy metals in the blood stream of an individual can vary according to various factors such as dose, route of exposure, age, gender, genetics, and nutritional status of the individual. Data also indicated an insignificant increase in the essential metals level in the blood donor group when compared with the reference range. Zinc and Copper are essential metals derived from foods such as beef, ground beef, legumes, potato, nuts and seeds poultry, ready-to-eat, hot cereals.and pork [17]. Zinc is a component of more than 200 enzymes, involved in various activities, such as metabolic functions, immunity and wound healing [18]. Copper is an essential nutrient that is widely spread in food and water. It is a part of several metalloenzymes that are required for oxidative metabolism, including cytochrome oxidase, feroxidase, amino oxidase, superoxide dismutase, ascorbic acid oxidase and tyrosinase [19].

Likewise, the level of toxic metals and essential metals were compared among different blood groups. There was no significant difference in the serum concentration of lead among group A, B, AB and O donors (P>0.05). Also the serum concentrations of cadmium, zinc and copper were similar among the different blood groups (P>0.05) These findings are consistent with the report of Emokpae et al. (2020), in Edo State, Nigeria.

Analysis of lead, cadmium, zinc and copper concentrations in the serum of male blood donors when compared to females was not statistically significant (P>0.05). These findings were also similar with the previous report of Emokpae et al. (2020),

Data from this study also indicated an insignificant difference in the mean serum concentration of lead and cadmium (P>0.05) in the different age groups among blood donors. Furthermore there was no significant difference between the mean serum concentrations of Zinc and Copper (P>0.05) in the different age groups among blood donors. Trace elements are needed for many metabolic and physiological processes in the human body [20]. Alterations in iron (Fe), zinc (Zn) and copper (Cu) levels in the sera change during inflammation and infections. These are associated with elevated levels of acute phase proteins, such as ceruloplasmin [21-23]. Zinc is a component of more than 200 enzymes, involved in various activities, such as metabolic functions, immunity and wound healing [18]. Consequently, zinc deficiency could disrupt the function of both signaling molecules and proteins directly involved in DNA replication and repair. Limited availability of cellular zinc due to zinc deficiency could result in a loss of activity of zinc-dependent proteins involved in the maintenance of DNA integrity and may contribute to the development of cancer.

5. CONCLUSION

The observed blood levels of cadmium and lead in donor blood banked designated for transfusion in this study were in correlation with the permissible range of toxic metals. More so, there was an insignificant increase in the essential metals level in the blood donor group when compared with the reference range. This study therefore concludes that donor blood designated for transfusion at Igbinedion university teaching hospital Okada had metal concentrations that is within the estimated tolerable range.

CONSENT AND ETHICAL APPROVAL

Ethical approval was sought and obtained from the Institutional Ethics Committee of the Igbinedion University Teaching Hospital, Okada, Edo State. Informed written consent and verbal communication relating to the aims of the study were administered to participants. Each recruit was identified by means of serial numbers rather than names to ensure confidentiality

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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DOI:10.1016/j.transci.2021.103067

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95332