Original Research Article

EVALUATION OF LEAD AND CADMIUM LEVELS IN INDIVIDUALS EXPOSED TO CEMENT DUST

Abstract

Background: Heavy metals such as lead and cadmium, which are present in cement dust, are elements with a density of more than 5 g/cm^3 that are harmful to both the environment and living creatures. This study was set out to evaluate levels of lead and cadmium in individuals exposed to cement dust in Nnewi metropolis.

Study Design: This case-control study was carried out among male and female workers in cement depots in Nnewi metropolis who were selected by simple random sampling.

Methods: Thirty-five individuals exposed to cement dust defined as test participants and thirty-five individuals not exposed to cement dust defined as control participants within the age range of 18 and 51 years were selected into this study. Test participants were sub-grouped based on years of exposure to cement dust into 3years and below, 4 to 6 years and 7 years and above. Five millilitres of whole blood was collected from each selected participant and levels of lead and cadmium were determined using atomic absorption spectrometry. Data were analysed using Independent Student's T-test and ANOVA with least significant differencepost hoc. Data was presented as mean ± standard deviation and significance level was taken at $p< 0.05$.

Results: The blood levels of lead and cadmium in test participants were significantly higher than blood levels in control participants. The lead levels were significantly higher in test participants exposed to cement dust for 7 years and above than in test participants exposed to cement dust between 4 to 6 years and test participants exposed to cement dust for 3 years and below ($p<0.001$). There was no significant difference in serum levels of cadmium between test participants exposed to cement dust for 3 years and below, test participants exposed to cement dust between 4 years to 6 years and test participants exposed to cement dust for 7 years and above ($p>0.05$).

Conclusion: Occupational exposure to cement dust causes high blood levels of lead and cadmium in the bodyand this accumulation is dangerous to health.

Key-words: Lead, Cadmium, heavy metals, cement dust,heavy metals, cement loaders

1.0 Introduction

"Heavy metals are defined as elements with a density more than 5 g/cm^3 that can harm both the environment and living creatures".[1]"These metals are needed for maintaining numerous biochemical and physiological activities in living organisms at low concentrations, but become toxic at higher amounts".[2]"Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons".[3] Cadmium and lead are among the most common heavy metals which cause risks for human health and the environment[4,29,30]and exposure to these metals has been increased by industrial and anthropogenic activities and modern industrialization.[5]"Contamination of water and air by toxic metals is an environmental concern and hundreds of millions of people are being affected around the world"[5]. The cement industry is a rapidly expanding industrial sector that drives Nigeria's industrial and infrastructure development [6]. The cement industry is a major polluter, producing dust to be dispersed by wind, rain, and other means [7]. "The biological responses exerted by the deposited dust particles cause a basic reaction leading to higher pH values that irritate exposed mucosal membranes, which

UNDER PEER REVIEW

could lead to respiratory symptoms or failure [7]. Heavy metals have acute and persistent harmful effects on various organs causing gastrointestinal and kidney problems, issues with the neurological system, skin lesions, vascular damage, effects on the immune system, birth defects as well as cancer"[8]. The aim of the study is to evaluate the blood levels of lead and cadmium in individuals exposed to cement dust.

2.0 Materials and Methods

Study Design

This case-control study was carries out among randomly selected male and female workers in cement depots in Nnewi metropolis.

Study participants

Thirty-five (35) individuals, aged between 18 and 45 were recruited as test participants while 35 apparently healthy individuals, 18 and 45 with no history of persistent exposure to cement dust were recruited as controls. The test participants were further categorized based on duration of exposure to cement dust into 3 years and below, 4years to 6 years and 7 years and above.

Sample Collection

Five (5) millilitres of whole blood was collected aseptically from each of the recruited participants and dispensed into EDTA containers and stored at between 2^0C to 8^0C until day of analysis.

Sample Analysis

Whole blood sample in anticoagulant tube was digested using aqua regia ($1HNO_3$:3HCl) in a conical flask and allowed to cool. Digestion was done as follows; Blood Samples were collected and transferred to a clean, sterile container; slowly about 10ml of aqua regia was added to the blood sample while stirring; the mixture was allowed to digest overnight, at room temperature; after digestion, the resulting solution was diluted to 100ml using deionized water to reduce acidity and prevent damage to analytical instruments; the digested and diluted samples were analyzed against a known concentration of the various minerals using atomic absorption spectroscopy (AAS) at a wavelength of .The (Buck Scientific 205) Atomic Absorption Spectrophotometer was used for this analysis at a wavelength of 228.8nm for cadmium and 217nm for lead. Standards of the different elements were prepared and used to calibrate the machine just before analysis.

Followingassays, the concentration in ppm of the various element were subjected to statistical analysis.All obtained data were analysed using Statistical package for social science (SPSS) version 23. Differences between mean values were obtained using Independent Student's T-test; difference between group means were obtained using analysis of variance (ANOVA) with least significant difference (LSD) post hoc. Data was presented as mean ± standard deviation (SD) and significance level was taken at p<0.05.

3.0 Results

The mean ± SD lead (16.11± 13.49µg/dL) and cadmium levels (0.21 ± 0.40µg/dL) in test participants were significantly higher than in control participants (lead – 3.42± 5.10µg/dL, p= 0.000, cadmium – 0.76± 0.75µg/dL, p= 0.043), p > 0.05 was considered significant (Table 1).

Table 1: Mean ± Standard Deviation of lead and cadmium levels in all participants with

Parameter	Test n = 35	Control n = 35	t-value	p – value
Pb (µg/dL)	16.11 ± 13.49	3.42 ± 5.10	5.202	0.000*

Cd (μg/dL)	0.76 ± 0.75	0.21 ± 0.40	2.058	0.043*

* is significant
Pb: Lead Cd: Cadmium t-value: Independent's t-test value

The mean lead and cadmium levels of test participants exposed to cement dust for 3 years and below (Group 1), test participants exposed to cement dust between 4 years to 6 years (Group 2) and test participants exposed to cement dust for 7 years and above (Group 3) were compared using ANOVA and LSD post-hoc. As shown in table 2, there were significant difference in mean levels of lead between test participants exposed to cement dust for 3 years and below, test participants exposed to cement dust between 4 years to 6 years and test participants exposed to cement dust for 7 years and above ($F= 10.995$, $p< 0.000$). However, there was no significant difference in mean levels of cadmium between test participants exposed to cement dust for 3 years and below, test participants exposed to cement dust between 4 years to 6 years and test participants exposed to cement dust for 7 years and above ($F= 1.801$, $p> 0.05$). On post-hoc analysis, mean lead levels were significantly higher in test participants exposed to cement dust for 7 years and above than in test participants exposed to cement dust between 4 to 6 years and test participants exposed to cement dust for 3 years and below ($p= 0.000$, $p= 0.033$). No significance difference was seen in mean cadmium levels of test participants exposed to cement dust for 7 years and above and in test participants exposed to cement dust between 4 to 6 years and test participants exposed for 3 years and below ($p= 0.978$, $p= 0.110$).

Table 2: ANOVA in test participants based of their duration of exposure to cement dust

Group	**N**	**Pb (μg/dL)**	**Cd (μg/dL)**
Test participants exposed to cement dust for 3 years and below (1)	12	5.83 ± 8.02	0.13 ± 0.07
Test participants exposed to cement dust between 4 years to 6 years (2)	11	15.81 ± 10.97	0.12 ± 0.08
Test participants exposed to cement dust for 7 years and above (3)	12	26.33 ± 12.64	0.39 ± 0.66
F – value		10.995	1.801
P – value		0.000*	0.181*
1 vs 2		0.033*	0.978
1 vs 3		0.000*	0.110
2 vs 3		0.025*	0.112

* is significant
Pb: Lead
Cd: Cadmium

4.0 Discussion

UNDER PEER REVIEW

“This study was carried out to evaluate the lead and cadmium levels of individuals (male cement loaders and female cement sellers) exposed to cement dust in Nnewi metropolis hence the following findings. Blood Lead level was higher in persons exposed to cement dust compared to individuals who were not exposed to cement dust. This could be as a result of the concentration of lead found in cement which could be attributed to the raw materials (limestone, shells and chalks heated along with shale, clay, slate, blast furnace slag, silica sand and iron ore) used in the production of cement”.[9, 10]“This finding is in line with a similar study carried out by[11] on cement dust exposure and perturbations in some elements and lung and liver functions of cement factory workers where serum levels of lead and other heavy metals in cement workers and residents living near cement factory who had higher levels of lead and other heavy metals when compared to unexposed control participants”.[11]“Also in the study conducted by Gebrie*et al*. on elevated blood lead levels among unskilled construction workers in Jimma, Ethiopia where the blood lead levels of male and female construction workers were higher than that of the unexposed group”.[12]“This study also reveals that lead levels were lower in individuals (cement loaders and cement sellers) exposed to cement dust for 3 years and below than in individuals (cement loaders and cement sellers) exposed to cement dust for more than 3 years. The lead levels were higher in individuals exposed for 7 years and above than in individuals (cement loaders and cement sellers) exposed to cement dust for 7 years and below. This difference may be attributed to duration of exposure of cement dust which is a determining factor of exposure to any hazardous substance and others being the route of the exposure and concentration of substances”.[11]“The level of toxicity found in short term exposure may be remedied, but the long-term toxicity is associated with undesirable health consequences”.[11]“In conclusion, lead is a harmful environmental pollutant which has high toxic effects to many body organs. Even though lead can be absorbed from the skin, it is mostly absorbed from respiratory and digestive systems. Increased lead exposure in the blood can induce neurological, respiratory, urinary, and cardiovascular disorders due to immune-modulation, oxidative, and inflammatory mechanisms”.[13]“Furthermore, lead could disturb the balance of the oxidant–antioxidant system and induce inflammatory responses in various organs. Schober *et al*. reported the association of chronic exposures to high occupational lead with atherosclerosis and cardiovascular mortality”.[14]“The international level-of-concern for lead poisoning is 10 µg/dl in the blood”.[15][13]

“This study reveals high levels of cadmium in individuals exposed to cement dust when compared to individuals not exposed to cement dust. This could be also as a result of the concentration of cadmium found in cement which could be attributed to the raw materials (lime, silica, alumina, iron oxide, magnesium oxide, sulphur trioxide and alkalies) used in the production of cement”.[10] This agrees with the research conducted by Omigie*et al*. on evaluation of serum cadmium, zinc and chromium in male cement loaders in Benin city, Nigeria.[16] The serum levels of cadmium, zinc and chromium in male cement loaders in Benin city, Nigeria were assessed and compared with unexposed participants. The study revealed an increase in serum concentration of cadmium and these other heavy metals in male cement loaders than in their control participants.[16] Another study conducted by Richard *et al*. on cement dust exposure and perturbations in some elements and lung and liver functions of cement factory workers also reported high serum levels of cadmium in individuals exposed to cement dust when compared to unexposed controls.[11] A contrary finding was reported in a study conducted by Demir *et al.* on nickel and cadmium concentrations in plasma and Na^+/K^+ ATPase activities in erythrocyte membranes of people exposed to cement dust emission.[17] The cadmium concentrations were found to be within the reference values for people exposed to cement dust and people not exposed to cement dust and no difference was found between the test participants and controls.[17] This study observes, however, that there was no significant difference in levels of cadmium between individuals (cement loaders and cement sellers) exposed to cement dust for 3 years and below, individuals

UNDER PEER REVIEW

(cement loaders and cement sellers) exposed to cement dust between 4 years to 6 years and individuals (cement loaders and cement sellers) exposed to cement dust for 7 years and above. This could be attributed to the concentration of cadmium found in cement dust. The concentration of heavy metals in cement increased in the order of Cd< Cr< Cu< Pb< Zn with cadmium being least according to the research conducted by Awuah *et al*.[10] The concentrations of these heavy metals in cement have been reported to be factory-dependent based on the raw materials (limestone, shells and chalks heated along with shale, clay, slate, blast furnace slag, silica sand and iron ore) used.[18]In conclusion, acute or chronic inhalation of cadmium in industrial areas might lead to renal tubular dysfunction and lung injuries.[19]In a related research, high cadmium concentrations were measured in kidneys (16.0 µg/g) and liver (1.5 µg/g), as cadmium is mainly distributed into these two internal organs.[20]The international level-of-concern for cadmium in the blood is 0.09 to 0.11µg/dl.[21] Increased cadmium concentrations in serum causes a lot of effects in the body which include displacement of the function and behavior of essential metals. For instance, similar to zinc, cadmium binds to albumin in plasma and consequently dysregulation of calcium, zinc, and iron homeostasis occurs.[22] Cadmium-induced liver injury may be associated with the disturbance of calcium (Ca) homeostasis.[23] Osteoporosis and bone fracture could be observed following cadmium toxicity.[24] Cadmium osteotoxic effects might be due to the decreased levels of serum PTH at high cadmium body burden which in turn induces calcium release from bone tissue.[26] Increased cadmium concentration may give rise to the occurrence of the kidney, lungs, pancreas, breast, prostate, and GI cancers. [26][27]High risk of chronic kidney disease and end-stage renal disease has been observed in cadmium accumulation.[27]

5.0 Conclusion

Occupational exposure to cement dust causes high blood levels of lead and cadmium in the body and this accumulation is dangerous to health. Safety measures should be put in place such as the compulsory use of personal protective equipment by cement workers.

6.0 Recommendation

We recommend that a further study on other heavy metal composition of cement dust should be studied to determine their levels in cement depot workers.

Consent: A written informed consent was obtained from all participants of this study.
Ethical Approval: Ethical approval was obtained for the Research and Ethics Committee of Faculty of Health Sciences and Technology, NnamdiAzikiwe University, Nnewi Campus.

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UNDER PEER REVIEW

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