ORIGINAL ARTICLE

Oxidative DNA Damage and Pro-inflammatory Response in Chronic Exposure to Cement Dust

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Abstract

Background: Inflammatory cell activation, oxidative stress and oxidative DNA damage have been associated with exposure to cement dust. Biomarkers of oxidative stress, oxidative DNA damage, inflammation and heavy metals were estimated in cement loaders.

Methods: Ninety men (45 cement loaders and 45 controls) were recruited into this comparative cross-sectional study. Total antioxidant capacity (TAC), total plasma peroxides (TPP), malondialdehyde (MDA), reduced glutathione (GSH), nitric oxide (NO) and uric acid (UA) were estimated by colorimetry, arsenic (As), chromium (Cr) and cadmium (Cd) by atomic absorption spectrophotometry and tumor necrosis factor alpha (TNF-α), 8-hydroxy-2-deoxyguanosine (8-OHdG) by enzyme linked immunosorbent assay.

Results: Cement loaders had increased lipid peroxidation (MDA, TPP, OSI), inflammation (TNF-α) and heavy metals (As, Cr) and lower antioxidants (UA, TAC, GSH) compared to controls ($p<0.05$). Increasing duration of exposure to cement dust was associated with higher lipid peroxidation, Cd, TNF-α and oxidative DNA damage (8-OHdG) ($p<0.05$). Negative correlation was observed between TAC and duration of exposure ($r=-0.375$, $p=0.011$) and positive correlations between TPP and duration of exposure ($r=0.614$, $p=0.000$), TNF-α and 8-OHdG ($r=0.492$, $p=0.001$) in cement loaders.

Conclusion: Chronic exposure to cement dust is associated with depletion of antioxidants, increased lipid peroxidation, oxidative stress, inflammation and oxidative DNA damage. These may be implicated in the development of chronic lung conditions.

Key words: Cement; Heavy Metals; Inflammation Oxidative Stress

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INTRODUCTION

Chronic exposure of cement workers to cement dust, by inhalation, ingestion and dermal contact, has been linked to multiple organ dysfunction and increased risk for chronic lung diseases including cancer. The development of these chronic conditions has been described as functions of degree of exposure and duration of exposure to cement dust. Heavy metal constituents of cement dust, such as cadmium (Cd), arsenic (As), chromium (Cr), mercury (Hg) and lead (Pb), have been implicated in the carcinogenic and toxic effects of cement dust on vital organs and systems (1). Chronic exposure to Pb, Cd and As in cement dust has been linked to the development of chronic obstructive lung disease, hematologic and immunologic disorders, cardiovascular complications, gastrointestinal toxicity, neurotoxicity, nephrotoxicity and cancer (2). The interaction of these metal ions with bio-molecules and cell components, such as DNA and nuclear proteins, can lead to changes and mutations in DNA structure. This may result in modification of the cell cycle and carcinogenesis (2, 3). Pathologic mechanisms of cement dust induced toxicity may include production of free radicals as reactive oxygen species(ROS), depletion of antioxidants, lipid peroxidation, inflammation and oxidative stress induced apoptosis (4, 5). Inflammation leads to increased generation of ROS which further aggravates the inflammation. The preponderance of ROS leads to peroxidation of membrane lipids and bio-molecules which may lead to structural changes in the tissue and abnormalities in organ functions (6-8). Different steps in carcinogenesis, including cellular transformation, proliferation, promotion, invasion, angiogenesis and metastasis, have been linked to chronic inflammation (9).

Alterations in liver and cardiopulmonary functions, immunologic and haematological indices have been linked to chronic exposure to cement dust (4, 10). Assessment of these indices in occupationally exposed individuals may therefore be important in determining the level of exposure and those at risk for chronic health conditions including cancer. The levels of some heavy metals, oxidative stress indices, biomarkers of inflammation and oxidative DNA damage in relation to duration of exposure to cement dust were assessed in cement loaders to determine their potential as indices for monitoring exposure levels in these exposed workers.

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METHODS

Study area and design

This study was carried out in Calabar, Cross River State located in South South Nigeria from March to August 2017. It is a comparative cross-sectional study involving cement loaders occupationally exposed to cement dust as cases and non cement loaders not exposed to cement dust as controls. Before recruitment into the study, written informed consent was obtained from each study participant after a clear explanation of the study's aims and objectives. Ethical clearance and approval to conduct the study was obtained from Cross River State Ministry of Health's centre for clinical governance, research and training REC No. CRSMOH/RP/REC/2017/509. The ethical principles for medical research involving human subjects, as outlined in the Helsinki declaration of 1975 and subsequent revisions, were applied while conducting this study.

Selection of subjects

The subjects of this study were 90 men between the ages of 18 to 60 years, comprising 45 healthy controls not exposed to cement dust and a test group of 45 professional cement loaders who were selected based on simple random method. The cement loaders selected were individuals who were occupationally exposed to cement dust daily during their work, for greater than one year. The control subjects were individuals who have never been occupationally exposed to cement dust and do not reside in the vicinity of a cement factory or cement depot.

The anthropometric indices height and weight were measured and used in calculating the body mass index (BMI). Systolic and diastolic blood pressures were taken using a sphygmomanometer. Socio-demographic data was collected, including age, education, work history, years of exposure to cement dust, and use of personal protective equipment such as gloves and dust masks. Information on family and medical history of past illness, smoking habits, consumption of alcoholic beverages, and use of recreational drugs was also collected. Subjects with chronic illness, long term medication use, and history of alcoholism, cigarette smoking, or use of recreational drugs, were excluded from the study.

Sample collection

Seven milliliters of whole venous blood samples were randomly collected from all study participants into heparinized tubes. Random spot urine samples were also collected into clean universal containers. Plasma was separated by centrifugation at 500g for 5 minutes and the samples were stored at - 20^0C until analysis. Both blood and urine samples were collected after 7 hours in the work place and at close of work.

Laboratory methods

Estimation of uric acid

The enzyme-colorimetric method was employed in the analysis of uric acid using Roche-Hitachi, COBAS 311 automatic analyzer. Uric acid was cleaved to form allantoin and hydrogen peroxide catalyzed by uricase enzyme. The hydrogen peroxide formed oxidizes 4-aminophenazone in the presence of peroxidase to form a quinone-diimine dye. The absorbance of the dye is proportional to the uric acid concentration in the sample (11).

Creatinine reacts with picrate ion in an alkaline medium to yield an orange-red adduct

Creatinine reacts with picrate ion in an alkaline medium to yield an orange-red adduct

Estimation of urine creatinine

Creatinine reacts with picrate ion in alkaline medium to yield an orange-red adduct which is measured at 520nm (12).

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Estimation of tumor necrosis factor alpha (TNF-α)

Tumour necrosis factor alpha was estimated using enzyme linked immunosorbent assay method (ELISA). Test kits were procured from Elabscience USA. The TNF-α in the sample and standards were bound to antibody specific to TNF-α coated on the ELISA microplate and incubated with biotinylated detection antibody specific to TNF-α and Avidin-Horseradish peroxidase (HRP) conjugate. Free component was washed away and enzyme substrate added to react with the conjugate to give a coloured complex whose absorbance is proportional to the concentration of TNF-α in the sample (13).

Estimation of 8-hydroxy-2-deoxyguanosine (8-OHdG)

Enzyme linked immunosorbent assay method was used in the estimation of 8-OHdG with test kit procured from Elabscience (USA). The 8-OHdG in the sample or standard compete with a fixed amount of 8-OHdG on the solid phase supporter for sites on the biotinlylated detection antibody specific to 8-OHdG. The reaction mixture was incubated with Avidin-Horseradish peroxidase (HRP) conjugate, free components were washed away and enzyme substrate added reacts with the conjugate to give a coloured complex whose absorbance is proportional to the concentration of 8-OHdG in the sample (14).

Estimation of total plasma peroxides

TPP is determined based on the ferrous-butylated hydroxytoluene-xylenol orange complex (FOX-2) test system which is based on the oxidation of ferrous ions to ferric ions by various types of peroxides present in the serum sample; to produce a colored ferric-xylenol orange complex whose absorbance is measured spectrophotometrically at 560 nm (15).

Estimation of plasma total antioxidant capacity (TAC)

TAC is determined based on the reaction of hydrogen peroxide (H_2O_2) with ferric ion-ethylenediamine tetraacetic (Fe-EDTA) complex to form hydroxyl radicals (OH•). These ROS degrade benzoate leading to the release of TBARS (thiobarbituric acid reactive substance). The production of TBARS is suppressed by antioxidants present in the sample and this inhibition of colour development is termed the total

antioxidant of the sample measured spectrophotometrically at 532nm (16).

Calculation of oxidative stress index (OSI)

The oxidative stress index which is an indicator of the degree of oxidative stress is expressed as the ratio of total plasma peroxide (TPP) to total antioxidant capacity (TAC) (15).

$$OSI\ (\%) = \frac{TPP\ (\mu molH_2O_2/L)}{TAC\ (\mu mol/L)} \times 100$$

Estimation of Nitric oxide.

The Griess test was used for detecting total levels of nitrite or nitrous acid in samples. The NO-containing compounds in the serum combines with alpha-Naphthylamine to produce pink azo dye whose absorbance was measured at a wavelength of 540nm. The measurement of total nitric oxide metabolite (NOx) (total nitrite and nitrate levels) is used as a direct marker of in vivo NO production (17).

Estimation of Glutathione

Reduced glutathione estimation was done using the modified standard Ellman's method. The GSH in the sample reacts with Ellman's reagent (5-5'-dithiobis-2-nitrobenzoic acid (DNTB)) to form the chromophore 5-thionitrobenzoic acid (TNB) and GS-TNB whose absorbance is measured at 412nm (18).

Estimation of Malondialdehyde

Malondialdehyde formed from the breakdown of polyunsaturated fatty acids reacts with thiobarbituric acid to give a red colored complex. MDA serves as a convenient index for determining the extent of peroxidation (19).

Estimation of cadmium, arsenic and chromium by atomic absorption spectrophotometry (AAS)

Atomic absorption spectrophotometry analyses the concentration of elements in a liquid sample based on energy absorbed from certain wavelengths of light by the atoms of the elements in the sample; the amount of light absorbed is proportional to the concentration of the element in the sample (20).

Statistical analysis

Results are presented as mean ± SE. Data were analysed using Statistical Package for Social Sciences, SPSS version 20.0. Student's t-test was used to determine mean differences, analysis of variance for determination of variation within and among groups and Pearson correlation for association among variables at 95% probability level.

RESULTS

Prevalence of clinical symptoms in cement loaders.

The prevalence of clinical symptoms in cement loaders studied is shown in figure 1. Clinical symptoms such as burning eyes, dermatitis, chronic cough, sneezing, persistent headache and nasal congestion were observed in 22.2%, 33.3%, 15.6%, 24.4%, 33.3% and 20% of cement loaders studied, respectively. Such clinical symptoms were not observed in non cement loaders.

Anthropometric indices, blood pressure, heavy metals, biomarkers of oxidative stress, oxidative DNA damage and inflammation in cement loaders and non-cement loaders

Table 1 shows the mean age, body mass index (BMI), waist circumference (WC), systolic and diastolic blood pressure (SBP and DBP), UA, TPP, TAC, OSI, MDA, GSH, NO, 8-OHdG, TNF-α, As, Cd and Cr in cement loaders and controls. The DBP, TPP, OSI, MDA, TNF-α, As and Cr were significantly higher and GSH, TAC and UA lower in cement loaders compared to controls ($P < 0.05$). No significant

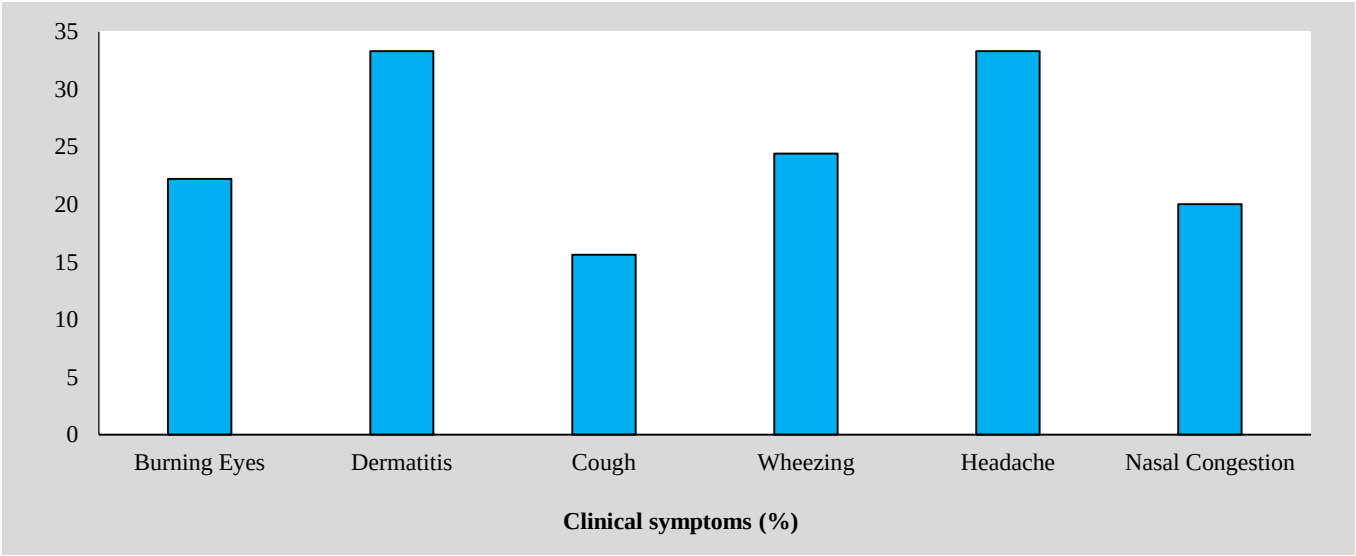

Figure 1. Prevalence of clinical symptoms in cement loaders.

differences (P >0.05) were observed in the SBP, 8-OHdG and Cd levels of the 2 groups.

Effect of duration of exposure to cement dust on biomarkers of oxidative stress, oxidative DNA damage, inflammation, and heavy metal levels in cement loaders and non cement loaders

Table 2 shows the effect of duration of exposure to cement dust on the levels of TAC, TPP, OSI, MDA, GSH, NO, 8-OHdG, TNF-α, UA, Cd, As and Cr in cement loaders. The Cd, TPP, MDA, 8-OHdG and TNF-α levels varied significantly with years of exposure to cement dust (P <0.05). The TAC, OSI, GSH, NO, UA, As and Cr did not vary with years of exposure to cement dust (P >0.05). Cement loaders who have been exposed for > 5 years had higher TPP, MDA, TNF-α, 8-OHdG and Cd levels than those exposed for < 5 years (P >0.05).

Table 1. Mean age, BMI, WC, SBP, DBP, UA, TPP, TAC, OSI, MDA,GSH, NO, 8- OHdG and TNFα in cement loaders and non-cement loaders.

Index	Cement loaders n=45	Controls n=45	p-value
Age (Yrs)	38.36±0.88	40.29±0.85	0.116
BMI (kg/m^2)	22.07±0.47	23.38±0.67	0.113
WC (cm)	78.14±1.04	84.44±1.86	0.004*
SBP (mmHg)	126.22±1.89	121.29±1.72	0.057
DBP (mmHg)	82.82±1.74	77.84±1.05	0.016*
UA (mg/dL)	4.39±0.22	5.16±0.16	0.006*
TPP (µmolH_2O_2/L)	498.77±24.71	346.84±6.04	0.000*
TAC (µmol/L)	1186.53±24.54	2193.02±22.96	0.000*
OSI (%)	43.03±2.25	15.90±0.34	0.000*
MDA (nmol/ml)	63.62±0.77	25.55±0.42	0.000*
GSH (µmol/l)	31.22±1.25	48.7058±7.65	0.029*
NO (µmol/l)	2.14±0.27	2.2062±0.26	0.857
8-OHdG (ng/mL)	54.23±6.67	45.59±6.86	0.369
TNFα (pg/mL)	34.81±4.97	2.284±0.11	0.000*
As (µg/L)	0.01±0.00	0.003±0.00	0.000*
Cd (µg/L)	0.04±0.00	0.024±0.01	0.164
Cr (µg/L)	0.03±0.00	0.01±0.00	0.000*

Data presented as mean±SD**,** *= significant at p<0.05, BMI= body mass index WC=waist circumference, SBP=systolic blood pressure, DBP=diastolic blood pressure,UA=uric acid, TPP=Total plasma peroxide, TAC=Total antioxidant capacity, OSI=Oxidative stress index, MDA=malondialdehyde, GSH=reduced glutathione, NO=nitric oxide, 8-OHdG= 8-hydroxy-2-deoxyguanosine, TNFα= Tumor necrosis factor alpha, As=Arsenic, Cd= cadmium and Cr= chromium.

Table 2. Effects of duration of exposure to cement dust on UA, TPP, TAC, OSI, MDA, GSH, NO, 8-OHdG, TNFα, As, Cd and Cr in Cement loaders.

Index	Duration of exposure (years)				
	1-<5 years n=24	5-10 years n=10	>10 years n=11	F ratio	p-value
UA (mg/L)	42.9±0.29	43.8±0.62	46.3±0.35	0.197	0.822
TPP (µmolH_2O_2/L)	30.88±1.84	38.94±2.92^b	49.42±2.35$^{a\ c}$	17.027	0.000*
TAC (µmol/L)	11.81±0.31	11.48±0.83	12.33±0.04	0.720	0.493
OSI (%)	47.14±3.26	38.81±5.34	37.90±2.41	2.003	0.148
MDA (mmol/ml)	47.96±6.45	73.46±16.25	88.86±22.51^a	1.482	0.238
GSH (mmol/l)	32.82±1.77	31.38±2.76	27.57±1.99	2.090	0.136
NO (µmol/l)	22.6±0.43	19.5±0.31	20.2±0.58	0.255	0.776
8-OHdG (ng/ml/gcreat)	41.51±6.32	49.52±15.08	86.27±16.57$^{a\ c}$	4.448	0.018*
TNFα (pg/ml)	26.47±6.32	31.99±6.20	55.58±12.46^a	3.211	0.049*

Table 2. Continued.

Index	Duration of exposure (years)				
As (µg/L)	0.01±0.00	0.01±0.00	0.01±0.00	0.333	0.719
Cd (µg/L)	0.03±0.00	0.04±0.00^{b}	0.04±0.00^{a}	7.484	0.002*
Cr (µg/L)	0.029±0.00	0.03±0.01	0.03±0.00	0.691	0.507

Data presented as mean±SD, * = indicate significant variations among groups at p < 0.05, a = indicate significant difference between 1-<5yrs and >10yrs at p < 0.05, b = indicate significant difference between 1-<5yrs and 5-10yrs at p < 0.05, c = indicate significant difference between 5-10yrs and >10yrs at p < 0.05, UA= uric acid, TPP= Total plasma peroxide, TAC= Total antioxidant capacity, OSI= Oxidative stress index, MDA=malondialdehyde, GSH=reduced glutathione, NO=nitric oxide 8-OHdG= 8-hydroxy-2-deoxyguanosine, creat=creatinine, TNFα= Tumor necrosis factor alpha, As= Arsenic, Cd= cadmium and Cr= chromium

The correlation plot of TAC against duration of exposure to cement dust in cement loaders is shown in figure 2. A significant negative correlation (r=-0.375, P =0.011) was observed between TAC and duration of exposure to cement dust.

Figure 3 shows the correlation plot of TPP against duration of exposure to cement dust in cement loaders. A significant positive correlation (r=0.614, P =0.000) was observed between TPP and duration of exposure to cement dust in cement loaders.

Association of inflammation with oxidative DNA damage in cement loaders

The correlation of 8-OHdG against TNF-α in cement loaders is shown in figure 4. A significant positive correlation (r=0.492, P =0.001) was observed between 8-OHdG and TNF-α in cement loaders studied.

DISCUSSION

Exposure to cement dust is associated with various health hazards emanating from the toxic components of cement, including heavy metals. Heavy metals induce generation of ROS leading to inflammation and oxidative stress which have been implicated in the development of acute or chronic respiratory diseases and increased risk for cancer (21). Biomarkers of oxidative stress, oxidative DNA damage, inflammation and heavy metals were evaluated in cement loaders in this study.

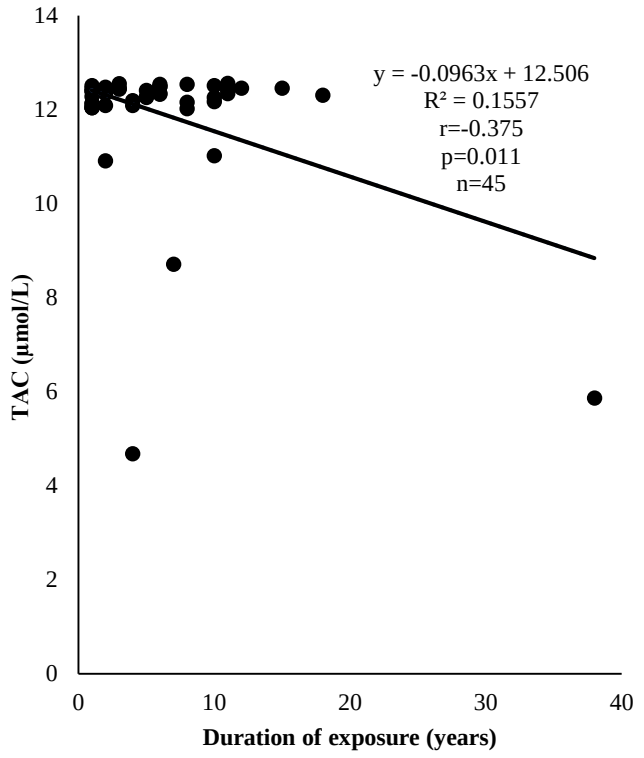

Figure 2. Correlation plot of TAC against duration of exposure to cement dust in cement loaders.

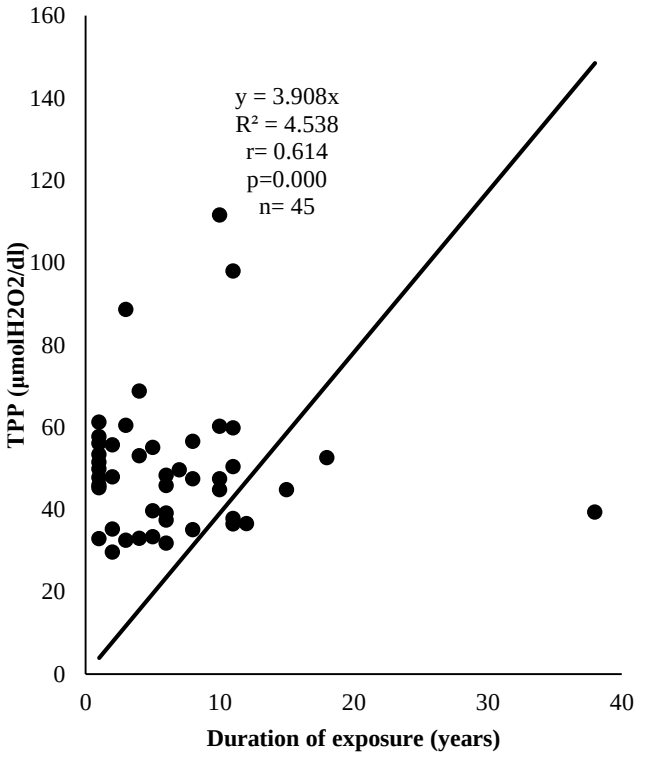

Figure 3. Correlation plot of TPP against duration of exposure to cement dust in cement loaders.

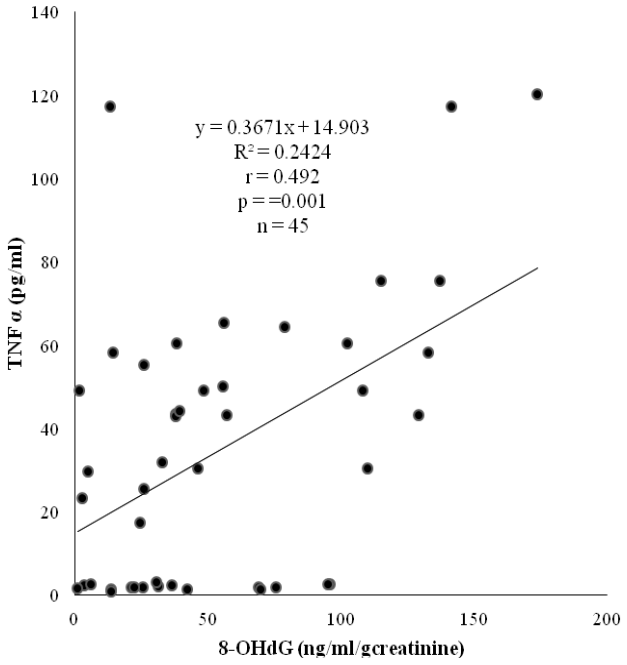

Figure 4. Correlation plot of TNF-α against 8-OHdG in cement loaders

In this study, clinical symptoms including burning eyes, dermatitis, chronic cough, sneezing, persistent headache and nasal congestion was prevalent among cement loaders but not among non cement loaders studied. Nasal congestion, shortness of breath, cough, wheezing, chest pain, eye and skin irritations are some of the allergic reactions associated with exposure to cement dust (22). The chromate and silicate content of cement dust and its alkalinity (pH 12) when in contact with mucus membranes has been implicated as possible inducers of airway inflammation (23). Cement-related dermatitis has been linked to skin irritation due to the alkalinity of cement or allergy to hexavalent chromium in cement (21). Sand and lime in cement dust can also have abrasive effects, leading to dermal abrasion. These effects are aggravated by occlusion due to wet clothes or shoes (24). Nasal manifestation has been linked to prolonged exposure of workers to chromium, which adheres to nasal mucus membranes (25). Respiratory symptoms among cement workers have also been reported (23). The effects of cement dust on the respiratory tract include narrowing of the airway, difficulty in breathing, respiratory tract irritation, increased mucus production and loss of cilia and cells lining the mucus membranes (26). No significant correlation was observed between clinical symptoms and duration of exposure to cement dust. Contrary to our findings, significant positive correlation has been reported between duration of exposure to cement dust and skin and respiratory complaints in cement workers (21).

Higher levels of As and Cr were recorded in cement loaders when compared to the controls. Cement production has been described as one of the major sources of heavy metal contamination in the environment(4). Cement dust has been shown to contain Cr VI derived from chromium steel grinders and refractory bricks in the kiln and other raw materials used in cement production (23). Occupational exposure to cement dust may therefore increase the systemic levels of As and Cr resulting in alteration in the homeostasis of some essential and toxic elements. Increased As and Cr levels were observed in United Cement factory workers when compared to non-workers (4).

The Cd level of the cement loaders was not significantly different from the levels in the control subjects. Comparable blood Cd levels have also been reported in workers occupationally exposed to cement dust compared to unexposed controls (27, 28). Contrary to our findings, significantly higher Cd levels have been described in workers exposed to cement dust compared to controls (4). However, higher Cd levels were reported in loaders who have worked for > 5 years compared to those who have worked < 5 years. Cadmium has been described as a human carcinogen that can bio-accumulate and that has a relatively long half-life (29). Low level cumulative exposure to Cd has been associated with perturbations in bone metabolism and renal functions (30). The dose, route of exposure, duration and frequency of exposure to metals are among the major factors contributing to bio-accumulation and subsequent toxicity of metals. Proposed mechanisms of metal induced toxicity include disruption of calcium homeostasis, disturbances in heme biosynthetic pathway, oxidative stress, lipid peroxidation, oxidative DNA damage and apoptosis (31). Disruptions in tumor suppressor gene expression and enzymatic activities involved in DNA damage repair processes with increased risk for cancer and other systemic diseases have been associated with exposure to cadmium (32, 33).

Cement loaders had significantly higher MDA, TPP and OSI compared to non-cement loaders. Increased lipid peroxidation as a result of both decreased antioxidant capacity and increased oxidative stress has been described in workers exposed to cement dust (34). Cement dust has been shown to induce increased generation of free radicals invitro or invivo in close proximity to cells (10). The resultant imbalance between the production of reactive species and their neutralization by the antioxidant defenses, leads to accumulation of ROS and their derived metabolites leading to imbalance in the redox state of the cell (35). The ensuing oxidative stress has been shown to be responsible for the oxidative disruption of the carbon-carbon double bonds of structural lipids. The outcome of this reaction, known as lipid peroxidation, disrupts biological membranes resulting in structural changes, membrane dysfunction and compromised membrane integrity (36). Increased lipid peroxidation associated with exposure to cement dust is responsible for higher levels of biomarkers of lipid peroxidation (TPP, MDA and OSI) seen in cement loaders compared to controls. Our findings are consistent with the findings of others who also reported higher MDA levels in cement workers compared to unexposed controls (6, 21). Increased oxidative stress has been observed in workers occupationally exposed to cement dust (37). Increased TPP and MDA levels were observed in workers who have been engaged for > 5 years compared to those engaged for < 5 years. This is an indication that lipid

peroxidation due to exposure to cement dust is aggravated by chronicity which will eventually lead to development of chronic lung conditions including cancer in the absence of appropriate intervention measures.

Lower TAC, uric acid and reduced glutathione concentration were recorded in cement loaders compared to non-cement loaders. The lower levels of TAC recorded in cement loaders may be a result of their increased utilization in neutralizing the detrimental effects of ROS associated with exposure to cement dust. Glutathione plays important role in protection of cells and bio-molecules against oxidative damage. Reduced GSH and glutathione peroxidase play significant roles in degradation and detoxification of cytotoxic and carcinogenic compounds including ROS (6). This finding is corroborated by the observation of significant negative correlation between GSH and MDA in cement loaders. This implies that lower GSH levels seen in cement loaders are a consequence of its utilization in ROS neutralization. Uric acid is derived from purine metabolism (degradation of nucleic acids, adenine and guanine). It is a marker of acute, severe and chronic inflammatory states (38). Uric acid has also been described as a metabolic or endogenous antioxidant and acts as a repair agent of oxidative DNA damage. The uric acid in the cement loaders may have been consumed in the process of neutralization of ROS associated with exposure to cement dust. Contrary to our findings, higher levels of uric acid have been reported in Nigerian cement loaders when compared to unexposed individuals (10).

Cement loaders had a comparable level of 8-OHdG as their control counterparts. Comparable levels of 8-OHdG seen in cement loaders may be attributed to the cell property of being able to effect rapid damage repair and recovery when exposed to toxicants as cement dust [39]. Contrary to our findings, significantly higher levels of 8-OHdG have also been reported in cement exposed workers when compared to controls (37). Cement loaders who had worked for > 10 years had higher levels of 8-OHdG compared to those who had worked for < 10 years. This may imply that cellular damage in cement loaders is aggravated by chronicity of exposure to cement. Mutagenic effects of cement dust include chromosomal aberration, disruption of the cell cycle, DNA replication and repair with increased risk for cancer (40).

Higher TNF-α level were observed in cement loaders compared to non-exposed controls. Cement dust inhalation irritates the mucous membrane of the respiratory tract and also stimulates inflammatory response in the airways of the workers resulting in significant increase in the level of airway neutrophils and other inflammatory markers with increased risk of developing occlusional pulmonary diseases including asthma, chronic bronchitis or silicosis (41). A similar observation of higher levels of TNF-α in factory workers occupationally exposed to cement dust has been reported. Higher serum levels of pro-inflammatory cytokines (serum IL- 1β, IL-2, IL-4, IL-10, TNF-α and interferon-gamma) have been reported in cement masons suggesting that masons may be at greater risk of a systemic inflammatory state that is potentially linked to immune dysregulation (42). Cement loaders who have worked for > 10 years had higher TNF-α levels compared to those who worked < 5 years. Higher TNF-α levels observed with increasing duration of exposure to cement dust may be attributed to their systemic inflammatory response to components of cement dust. Silica in cement has been shown to induce inflammatory responses leading to secretion of cytokines, lytic enzymes, chemotactic factors and ROS (10). A positive correlation was observed between 8-OHdG and TNF-α in the cement loaders studied. This observation may imply that inflammatory response associated with exposure to cement dust is accompanied by a corresponding increase in ROS generation, oxidative stress and hence oxidative DNA damage and increased risk for carcinogenesis.

CONCLUSION

Our findings have shown that chronic exposure to cement dust is associated with elevated heavy metals levels, oxidative stress accruing from depletion of antioxidants and increased lipid peroxidation leading to oxidative DNA damage, inflammation and increased risk of development of chronic lung conditions among cement loaders. Compulsory use of personal protective devices should be enforced among cement loaders to avert deleterious health consequences.

LIMITATION

The major limitation of this study is small sample size. The study has established an association between exposure to cement dust with increased inflammation, oxidative DNA damage and risk of chronic lung conditions.

Conflict of Interest: None to be declared.
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