

Full Length Research Paper

Immunomodulatory effects of cement in exposed workers

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This study was conducted to assess the immunomodulatory potentials [immunoglobulin E (IgE), interferon-gamma (IFN- γ) and tumor necrosis factor-alpha (TNF- α)] of cement dust in individuals occupationally exposed to cement. Potentials of cement particles to modulate immune responses have not been documented in occupationally exposed Nigerians. Twenty-nine male cement loaders who had direct exposure to cement dust and gases for a period of 2 to 30 years in Elephant/Lafarge Cement Depot Ibadan, Nigeria, were recruited for this study. Another twenty apparently healthy individuals who had no interaction with cement served as controls. Plasma levels of IgE, IFN- γ and TNF- α were determined in them using enzyme linked immunosorbent assay (ELISA) methods. The results showed significantly ($p < 0.05$) higher level of plasma IgE in cement loaders compared with controls. IFN- γ decreased significantly ($p < 0.05$) in cement loaders, while TNF- α did not show significant ($p > 0.05$) change in the cement loaders compared with controls. There was no significant ($p > 0.05$) correlation between the IgE, IFN- γ , TNF- α and period of exposure in the cement loaders. Cement dust could evoke IgE production and possibly inhibit certain cell types secreting IFN- γ in occupationally exposed workers. Clinicians and researchers may need to rule out recent exposure to cement dust when working on type I hypersensitivity conditions.

Key words: Cement, allergen, Interferon- γ , necrotic factor-alpha.

INTRODUCTION

Cement dust basically contains calcium oxide, silicon oxide, aluminium oxide, iron oxide, potassium, sodium, sulphur, magnesium oxide, cobalt and heavy metals like chromium, chromium, nickel, lead and mercury (Fell et al., 2003; Gbadebo and Bankole, 2007). The cement dust

has a diameter ranging from 0.05 to 5.0 μ (Abrons et al., 1997) emitted in form of particulate matters or aerosol that can be ingested or inhaled by exposed individuals (Green, 1970). Heather (2003) reported that exposure to cement dust for a short period may not cause serious

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problems. However, prolonged exposure can cause severe irreversible damage to plants and animals. Pathological effects of cement dusts have been reported in some visceral organs including lungs, kidney and liver (ATSDR, 2000; Abrons et al., 1988). Other studies have reported increased free radical generation and inflammatory responses in workers exposed to cement dust. Ikli et al. (2003) stressed that in organs like kidneys, skin and liver, cellular activation in response to the cement particulate matters leads to inflammatory responses and excessive production of reactive oxygen species. Akiibinu et al. (2016) reported that excessive macrophage activation, oxidative DNA damage, kidney diseases and chemically-induced tumors are imminent in cement exposed workers. Koh et al. (2013) observed increased cancer incidence in the cement exposed workers.

There are studies linking exposure to cement dust with changes in lung functions and inflammation of the peripheral lung (Mengesha and Bekele, 1997; Mwaiselage et al., 2005; Sauni et al., 2012). Several reports on respiratory diseases in long-term cement-dust exposed workers revealed irritation of the exposed mucous membranes (Schwartz, 1994; Sivicommar et al., 2001; Zeleke et al., 2010). Other studies show that inhaled cement particles cause activation of alveolar macrophages, mesothelial cells and lung fibroblasts that may contribute to higher plasma levels of free radicals and some products of cellular activation in the cement exposed workers (Aminian et al., 2008; Zeleke et al., 2010). There is increasing evidence that respiratory sensitization by allergens is associated with the preferential activation of Th-2 cells and their products, for example, interleukin (IL)-4, IL-5, IL-10, and IL-13; that favor type 1-hypersensitivity reactions and promote IgE antibody production (Dearman et al., 2003). Certain constituents of cement products including acrylates, nickel, cobalt, chromium and polymerization additives in bone cement (for example., benzoyl peroxide) have been implicated as triggers of eczema, wound healing disorders, and aseptic implant loosening (Fröschen et al., 2018; Chen et al., 2018).

Most of the previous studies have evaluated the effects of cement dust exposure on lung disorders by using spirometry or radiology. No one has attempted to study the antigenic potentials of cement particles and status of cellular activities in cement loaders. This study was therefore designed to bridge this gap in knowledge by determining the plasma levels of IgE, IFN- γ and TNF- α in Nigerian cement loaders.

MATERIALS AND METHODS

Sample collection

Twenty-nine cement loaders working in the Elephant/Larfage Cement Depot volunteered to participate in this study. These workers were untrained and lacked appropriate protective equipment that could prevent dermal, oral and lung contact with

cement particles. Another twenty apparently healthy individuals who had no interaction with cement served as controls. All participants were screened and found free from worm infections at the time of this study. The body weight and height of participants were taken, and the body mass index (BMI) calculated. Five milliliter of fasting blood sample was collected from each participant into lithium heparin bottle, centrifuged and the plasma stored at -20°C until ready for analysis. This study was approved by the Institutional Review Board (ref. no: CULREC 02/007), and informed consent obtained from all participants before the commencement of this study.

Determination of IgE, TNF- α and IFN- γ

Plasma level of IgE was determined using commercially prepared ELISA kits (cat. numbers T1244A) by Calbiotech Inc., 1935 Cordell Ct., El Cajon, CA 92020. Plasma levels of TNF- α and IFN- γ were determined using commercially prepared ELISA kits (cat. numbers EKHU-0162 and EKHU-0110 respectively) by Melsin Medical Co. Limited, Jilin Province, China. The methods employed for the determination of IgE, TNF- α and IFN- γ was provided by the manufacturers of the ELISA kits.

Statistical analysis

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS), version 21.0. The data were expressed as Mean \pm SD. Student T-test was used for comparison of analytes in cement loaders and controls. Pearson correlation coefficient (r) was calculated and P values less than 0.05 were considered significant.

RESULTS AND DISCUSSION

There were no significant ($p>0.05$) differences in the values of age, weight, height and BMI of the cement loaders and controls recruited for this study (Table 1). Plasma IgE increased significantly (201.9 ± 137.3 iu/ml versus 54.7 ± 45.3 iu/ml; $p=0.003$) in cement loaders compared with controls (Figure 1). IFN- γ decreased significantly (65.4 ± 14.9 pg/ml versus 151.6 ± 78.4 pg/ml; $p<0.001$) in cement loaders compared with controls (Figure 2). Level of TNF- α did not show significant (84.4 ± 50.8 pg/ml versus 109.9 ± 72.0 pg/ml; $p=0.24$) difference in the cement loaders compared with controls (Figure 3). There was no significant ($p>0.05$) correlation between the IgE, IFN- γ , TNF- α and period of exposure in the cement loaders (Table 2).

Workers in cement industries are exposed to different levels of dust. A geometric mean dust exposure of 38.6 mg/m³ was reported in the crusher section followed by 18.5 mg/m³ in the packing section, while the guards are exposed to only 0.4 mg/m³ (Mengesha and Bekele, 1997; Mwaiselage et al., 2005; Zeleke et al., 2010). Koike et al. (2008) and Fell et al. (2010) stressed that particulate matters can enhance antigen-related airway inflammation and immunoglobulin production. The cement packers (loaders) recruited for this study lacked protective gargets and are therefore prone to both dermal and lung exposure more than other workers in cement industry. Significantly higher level of plasma IgE observed in these

Table 1. Physical characteristics of cement loaders and controls.

Parameter	Controls (N=20)	Cement Loaders (N=29)	p-value
Age (years)	46.17±15.03	51.76±8.81	0.217
Weight (kg)	69.56±9.84	66.62±11.93	0.376
Height (m)	1.68±0.07	1.69±0.07	0.703
BMI (kg/m ²)	24.64±3.54	22.89±3.38	0.187

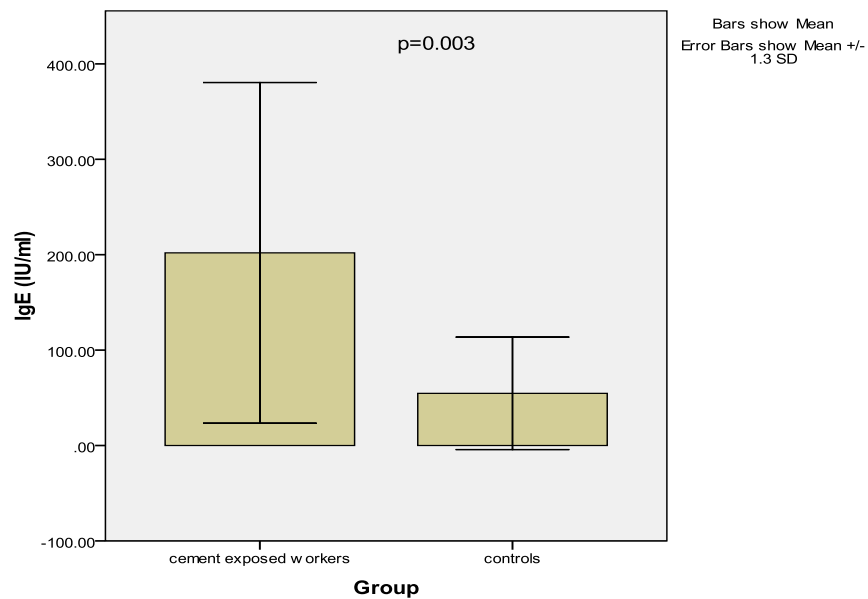


Figure 1. Levels of plasma IgE in cement loaders and controls.

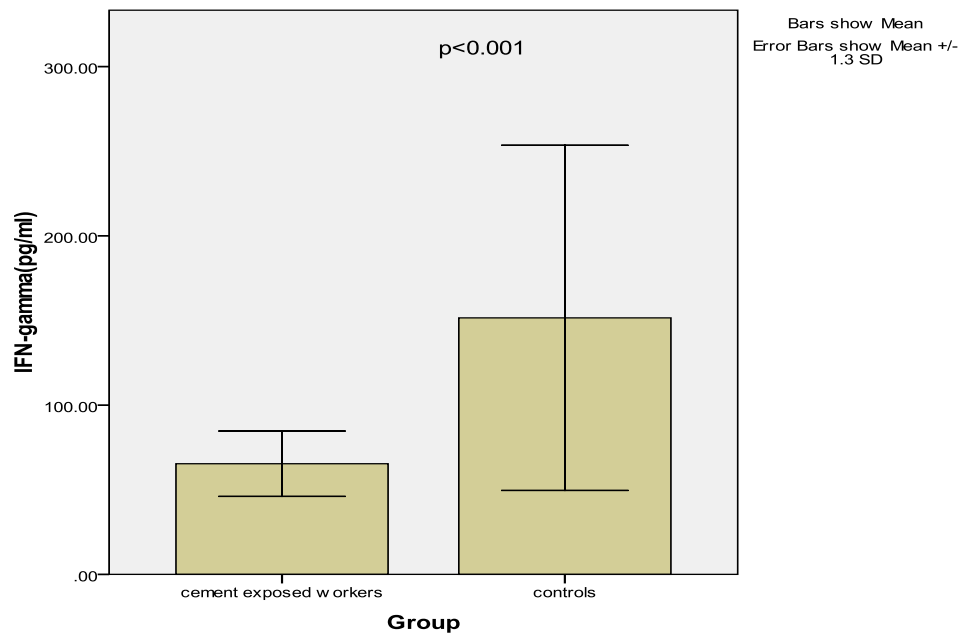


Figure 2. Levels of plasma IFN- γ in cement loaders and controls.

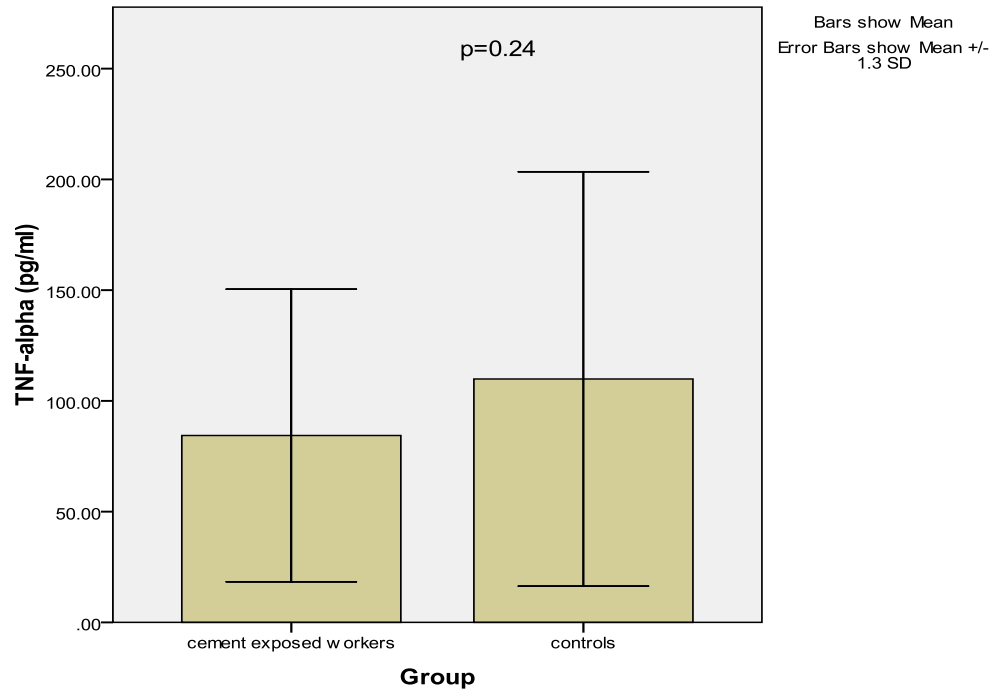


Figure 3. Levels of plasma TNF-alpha in cement loaders and controls.

Table 2. Correlation between the levels of IgE, TNF- α and IFN- γ and period of exposure (p/exp) in cement loaders (N=29)

Parameter	r-value	p-value
IgE/p/exp	-0.046	0.815
IgE/TNF- α	0.186	0.335
IgE/IFN- γ	-0.060	0.757

cement loaders could be due to allergic reactions induced by the cement particles. This study agrees with Ogunbileje and Akinosun (2011) who reported significantly higher level of IgE in some cement factory workers. Shankar et al. (2017) stressed that postcementation hypersensitivity is an unpleasant sensation experienced by their patients. Rahmani et al. (2018) reported allergy and other complication like hypertension, diabetes and backache in workers exposed to cement dust. Other previous studies show that dermal exposure to chromium content of cement causes skin irritation and activate keratinocytes in allergic contact dermatitis (Kanerva et al., 2000; Gueniche et al., 1994; Estlander et al., 2000; Kvitko, 2001; Thomas et al., 2000; Lejding et al., 2018). The chromium induces two types of hypersensitivity reactions: type I, anaphylactic type, and type IV, the delayed-type hypersensitivity (Thomas et al., 2000). Mowitz et al. (2016) reported that potassium dichromate and ethylenediamine dihydrochloride and/or amines used as additives in cement also induce contact

allergy in the cement exposed workers. Dearman et al. (2003) reported that allergic sensitization induced by chromate is associated with preferential activation of Th-2 cells and their products that favor immediate type hypersensitivity reactions, promoting IgE antibody production and clinical manifestations of allergic responses. Sarma (2009) also reported frequent allergic reaction among construction workers using cement. Other reports show that exposure to cement enhances IgG, IgA (Nigam et al., 1994; Aminian et al., 2008) and IgM production (Karnik et al., 1991). This chromate sensitization was found reduced with the usage of chromate-reduced cement (Geier et al., 2017). Possible inhibitory effects of some heavy metal constituents of cement (for example, nickel, chromium, lead and mercury) on tissue macrophages and natural killer cells might account for the lower level of IFN- γ observed in this study. This finding seems to agree with Castranova (2004) who reported inhibitory effects of heavy metals on oxidative metabolic processes in alveolar macrophages.

However, our report contradicts that of Carlsten et al. (2007) who reported significantly higher serum IFN- γ in cement-dust exposed apprentices. There was no significant change in the level of TNF- α induced by cement in the exposed workers. This could be due to the effects of some inhibitory factors antagonizing the activation of macrophages. In a research by Algan et al. (1996), it was stated that exposure of macrophages to polymethylmethacrylate (a component of cement) particles leads to a significant release of TNF- α after a long time of contact.

Conclusively, cement dust could evoke IgE production and possibly inhibit certain cell types secreting IFN- γ in occupationally exposed workers. Clinicians and researchers may need to rule out recent exposure to cement dust when working on type I hypersensitivity conditions.

CONFLICT OF INTERESTS

The authors have not declared any conflicts of interests.

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