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Health and Hematological Profile of Male Labourers in a Cement Factory in North-Central Nigeria

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ABSTRACT

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Prolonged exposure to cement dust is linked to respiratory and hematologic disorders, which may lead to further psychosocial problems. However, data on these associations remain limited. This case-controlled study investigated the relationships between cement dust exposure and respiratory and hematologic abnormalities among workers in a resource-limited setting. The study involved 80 cement workers and 80 healthy male controls, with a mean age of 31.37 ± 9.06 years. Cement workers were generally younger, more often smokers, and less frequently married or formally educated than controls. Despite receiving more occupational training and reporting higher use of personal protective equipment (PPE), cement workers experienced a higher prevalence of illnesses ($p=0.002$). Symptoms such as eye pain and itching ($p<0.001$), cough ($p<0.001$), dyspnea ($p<0.001$), and wheezing ($p<0.001$) were notably more frequent in this group, yet most did not receive any medical treatment ($p<0.001$). Hematologic assessments revealed significantly increased rates of neutrophilia ($p=0.001$), monocytosis ($p=0.003$), eosinophilia ($p=0.01$), and anaemia ($p=0.002$) in cement workers. The leucocytosis and lymphopenia were more common but not statistically significant ($p=0.07$ and $p=0.09$, respectively). Duration of exposure showed meaningful correlations with neutrophilia ($r=-0.49$), monocytosis ($r=-0.33$), eosinophilia ($r=-0.35$), and lymphopenia ($r=-0.42$). Contact with cement dust increases the likelihood of respiratory and hematologic disturbances, with insufficient training and suboptimal PPE practices possibly contributing to these outcomes. More prolonged exposure durations were associated with specific blood abnormalities. Strengthened collaboration between government bodies and cement industry operators, improved health insurance systems, targeted worker training, and consistent use of protective measures could help reduce the occurrence and impact of these health issues.

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INTRODUCTION

The progressive increase in urbanization occasioned by population increase and preference for “white collar jobs” have necessitated the construction of more houses, roads, bridges, and other facilities. The construction industry mostly involves artisans and manual labourers, typically involving the use of cement as one of the most important materials. Exposure to cement dust (concrete has 10-15% of its constituents as cement), more so when prolonged, could increase the risk of cement-associated disorders (Aliyu & Amadu, 2017; Kotawadekar *et al.*, 2024). Exposure to cement is documented to heighten the risk of acute and chronic cough, chronic obstructive lung diseases, asthma and pulmonary infections (Ahmad *et al.*, 2021). Inflammatory markers in sputum analysis and inflammatory occupational skin disorders (OSDs) are more common in construction workers than in the general population (Israel *et al.*, 2025).

Common injurious chemicals in cement include sand and oxides of silicon, aluminum, ferric, calcium, and magnesium (Kotawadekar *et al.*, 2024; Ahmad *et al.*, 2021). Crystalline silica can cause abrasion and injury to the respiratory tissues, which can lead to irritations to the eyes, nose, and throat, choking and dyspnea (Omidianidost *et al.*, 2019). The occurrence of cement-associated disorders depends on factors such as the concentration of the constituents, exposure time, and presence or absence of protective covers. These factors are more common in resource-challenged settings where precast concrete is less common despite global increases in mechanization (El Fattah *et al.*, 2023). The stressful states (hot, cold, wet and sunny weather) that are often associated with wide variations in humidity further heightens the risk of inhalational injury and could lead to increases in the risk and incidences of inhalational injury in resource-challenged settings (Meo *et al.*, 2013; Dushyant *et al.*, 2023).

Literature is still scarce in resource-challenged settings (RCSs) regarding the pattern and profile of cement-associated disorders among construction workers. We assessed in this community-based case-controlled study, the pattern and profile of cement-associated inhalational injury and hematologic derangement and determined its correlates in South West Nigeria.

MATERIALS AND METHODS

Study design and location

The prospective case-controlled study was conducted at the Dangote Cement PLC, Ilorin depot, and involved 80 cases and 80 controls who met the eligibility criteria and gave informed consent. The 80 cases were active construction workers at the depot, while the controls were healthy non-cement-exposed individuals.

Study population

All study participants were eighteen years old or more, were males, as was the case with the cement workers. The ten female non-cement workers of the company who hadn't worked at the factory for up to 12 months and four non-cement workers of the company who had worked at the factory for up to 12 months but declined consent, were excluded.

Inclusion criteria for cases

Cement workers 18 years old or older who gave informed consent and had worked at the factory site for a minimum of 12 months were recruited for the study.

Exclusion criteria for cases

Cement workers less than 18 years, who refused informed consent, and those who had not worked at the site for up to 12 months at the site were excluded.

Inclusion criteria for controls

Healthy individuals 18 years old or older who met the inclusion criteria and gave informed consent were recruited

Exclusion criteria for controls

Healthy individuals less than 18 years, who refused informed consent, had symptoms and signs of infections, obvious deformities and those with background medical conditions, particularly respiratory conditions such as allergy, atopy, asthma and chronic obstructive pulmonary disease, were excluded.

Study technique

A pre-tested questionnaire that was adapted from the occupational safety and health administration (OSHA, 2016) format was used to enter the data which included the sociodemographics, history of exposure to cement, smoking, the use of safety gadgets, general health, past and present medical history including possible occupational hazards (OSHA, 2016).

Minimum sample size estimation

The minimum sample size was calculated from the formula in a comparative study using the prevalence from a previous study

$N = (2z^2) pq/d^2$ (Noordzij *et al.*, 2010) where,

$2z$ = standard normal deviation set at 1.96, which corresponds to a 95% confidence level

P = prevalence of bronchitis among the population (13%)

q = 1.0 – p = 0.87

d = degree of accuracy desired or maximum allowable margin of error set at 0.05, having concluded that an observed difference of 0.1 or more is significant at the p-level of 0.05

$N = 2(1.96)^2 (0.13) (0.87) / 0.10^2 = 87$

One hundred cement and non-cement workers were each recruited as cases and controls. Fourteen non-cement workers had incomplete data, while ten cement workers left the company before the completion of the study; the twenty-four persons were subsequently excluded from the study, giving a sample size of 80 cases and controls.

Specimen collection: About 5 ml of venous blood was collected from each participant, and it was dispensed into an ethylene diamine tetraacetic acid bottle (EDTA). The full blood count was determined using the whole blood in EDTA.

Data analysis

Data generated from the study were entered into the Statistical Product and Service Solution (SPSS) V.25.0. Continuous variables presented as means with SD were compared using the paired Student's t-test. Categorical variables presented as proportions and percentages were compared using chi-square (χ^2). Univariate analysis was used to determine the association between the variables and inhalational injury. The multivariate model was used to determine

the independent associates of inhalational injury after adjusting for confounders. Statistical significance was considered at $p < 0.05$.

Ethical approval

Permission to conduct the study was obtained from the Ministry of Health, Kwara State (MOH/KS/EU/777/472). Written informed consent was obtained from eligible participants after they had been well educated on the objectives and format of the study. Confidentiality was duly observed as each participant's personally-identifiable information was altered, and participants' medical history, clinical and laboratory findings were anonymized.

RESULTS

A hundred and sixty male participants (80 cases and 80 controls) were involved in the study and their mean age was 31.37 ± 9.06 years. The largest proportion among the cases was within the 18-27 years range, but was within the 28-37 years range in the controls (Table 1). All participants had formal education and could read and write. Only 19 of the cement workers had worked in the factory for more than 6 years. Around 27.6% of the cases worked in the factory for more than 48 hours weekly, while none of the controls worked for more than 48 hours weekly, $p < 0.001$. The majority (58.75%) of the cases were current smokers, while the majority of the controls never smoked, $p < 0.001$.

Table 1: Socio-demographic and historical profile of the study population

Variables	Total n=160 (%)	Cases (%) n=80 (%)	Controls (%) n=80 (%)	P-value
Age, (mean \pm SD), years	31.37 \pm 9.06	31.60 \pm 8.7	31.49 \pm 9.0	0.22
18-27	57 (35.63)	29 (36.25)	28 (35.00)	
28-37	59 (36.88)	27 (33.75)	32 (40.00)	
38-47	35 (21.87)	20 (25.00)	15 (18.75)	
\geq 48	9 (5.62)	4 (5.00)	5 (6.25)	
Marital status				
Single	60 (37.50)	35 (43.75)	25 (31.25)	0.01
Married	92 (57.50)	39 (48.75)	53 (66.25)	
Divorced	8 (5.00)	6 (7.59)	2 (2.50)	
Education				
Primary	57 (35.62)	57 (71.25)	0 (0.0)	0.48
Secondary	44 (27.50)	23 (28.75)	21 (26.25)	
Tertiary	59 (36.88)	0 (0.0)	59 (73.75)	
Department				
Office workers	80 (50.00)	0 (0.00)	80 (100)	<0.001*
Cement mill	80 (50.00)	80 (100)	0 (0.00)	
Exposure to cement, years				
1-5	61 (38.12)	61 (76.25)	0 (0.00)	<0.001*
6-10	19 (11.88)	19 (23.75)	0 (0.00)	
\geq 11	0 (0.00)	0 (0.00)	0 (0.00)	
Smoking				
Never	111 (68.80)	33 (41.30)	78 (96.25)	<0.001*
Stopped	2 (1.25)	2 (2.50)	0 (0.00)	
Current	47 (30.00)	45 (56.25)	2 (3.80)	
Working hours/week				
<48	138 (86.25)	58 (72.50)	80 (100)	<0.001*
\geq 48	22 (13.75)	22 (27.50)	0 (0.00)	

*Fisher's exact test

Training for, and the use of PPE and the frequency of illnesses were higher in the cement workers compared to the controls, $p=0.018$, $p<0.001$, $p=0.002$, respectively (Table 2).

Table 2: Personal protective equipment and pattern of clinical illnesses in the study population

Variables	Total n (%)	Cases n (%)	Controls n (%)	P-value
Use of PPE				
Yes	133 (83.12)	77 (96.25)	56 (70.00)	<0.001*
No	27 (16.88)	3 (3.75)	24 (30.00)	
Training for PPE use				
Yes	84 (52.50)	56 (70.00)	28 (35.00)	0.018
No	76 (47.50)	24 (30.00)	52 (65.00)	
Pattern (frequency) of sicknesses				
Never	15 (9.38)	12 (15.00)	3 (3.75)	0.002*
Occasionally	38 (23.75)	26 (32.50)	12 (15.00)	
Sometimes	98 (61.25)	36 (45.00)	62 (77.50)	
Usually	9 (5.62)	6 (7.50)	3 (3.75)	
Always	0 (0.00)	0 (0.0)	0 (0.0)	

PPE-personal protective equipment

Irritative features of the eyes and the URT, cough, dyspnea, and wheezes were more common in the cement workers than the controls, $p<0.001$, $p<0.001$, $p<0.001$, and $p<0.001$, respectively (Table 3).

Table 3: Clinical history of the study population during the six month study

Variables	Total n (%)	Cases n (%)	Controls n (%)	P-value
Respiratory symptoms				
Yes	36 (22.50)	36 (45.00)	0 (0.00)	$<0.001^*$
No	124 (77.50)	44 (55.00)	80 (100)	
Treatment for respiratory symptoms				
Yes	22 (13.75)	22 (27.50)	0 (0.0)	$<0.001^*$
No	138 (86.25)	58 (72.50)	80 (100)	
Itching or pains in eyes or URT				
Yes	70 (43.75)	70 (87.50)	0 (0.00)	$<0.001^*$
No	90 (56.25)	10 (12.50)	80 (100)	
Cough				
Yes	62 (38.75)	61 (76.25)	1 (1.25)	<0.001
No	98 (61.25)	19 (23.75)	79 (98.75)	
Difficulty with breathing				
Yes	19 (11.87)	19 (23.75)	0 (0.0)	<0.001
No	141 (88.13)	61 (76.25)	80 (100)	
Wheezes (whistling)				
Yes	28 (17.50)	28 (35.00)	0 (0.00)	<0.001
No	132 (82.50)	52 (65.00)	80 (100)	

URT-upper respiratory tract

The white cell count and monocyte count were higher in the cement workers than the controls, $p=0.07$ and $p=0.003$, respectively (Table 4). The packed cell volume and lymphocyte count were lower in the cement workers than the controls, $p=0.007$ and $p=0.09$, respectively.

Table 4: Haematologic profile of the cement workers and the controls

Variables	Cases Mean \pm SD	Controls Mean \pm SD	t-test	P-value
Total WCC	6.71 \pm 4.96	5.29 \pm 1.71	1.09	0.07
Neutrophils	3.93 \pm 2.18	2.37 \pm 1.57	3.06	0.01
Lymphocytes	2.33 \pm 1.82	2.49 \pm 1.13	1.03	0.09
Monocytes	0.57 \pm 0.13	0.30 \pm 0.15	2.89	0.03
Eosinophil	0.05 \pm 0.01	0.03 \pm 0.01	2.44	0.04
Packed cell volume	37.42 \pm 4.73	39.58 \pm 5.17	2.51	0.02

WCC-white cell count

Anemia and leukocytosis in the cement workers had low to moderate correlation with the duration of exposure to cement ($r=-0.21$, $p=0.01$ and $r=0.18$, $p=0.001$, respectively (Table 5). Lymphopenia and eosinophilia had moderate to strong correlations with the duration of exposure to cement, $r=0.42$, $p=0.001$, and $r=0.35$, $p=0.02$, respectively.

Table 5: Correlation between haematological indices and duration of exposure to cement

Variables	r	P-value	Strength
Haematocrit, %	0.21	0.07	Low to moderate
Total WCC	0.18	0.08	Low to moderate
Neutrophil	0.49	0.03	Moderate to strong
Lymphocyte	0.42	0.03	Moderate to strong
Monocyte	0.33	0.04	Moderate to strong
Eosinophil	0.35	0.04	Moderate to strong

DISCUSSION

The study found a strongly positive correlation between longer working hours and respiratory symptoms, which were associated with exposure to airborne chemicals, and this led to higher frequencies of illnesses in cement workers compared to non-cement workers. Eosinophilia and anemia were more common in cement workers than in the controls, and anemia had a weak-to-moderate correlation with the duration of exposure. The findings mirror findings from earlier studies that associated inhalational injuries (arising from inflammation-induced injuries to the respiratory tissue mucosa) with exposure to cement dust (Al-Neaimi *et al.*, 2001). The most common constituents of cement include silicon oxide, calcium oxide, magnesium oxide, aluminium trioxide, ferric oxide, sand, and other impurities (Ogunbileje *et al.*, 2013). The higher bundle of the symptom complex could be attributed to the low humidity that tends to enhance the occurrence of airborne-associated diseases. These inhalational diseases are among the most commonly reported occupational diseases. Similarly, most occupational lung diseases are associated with inflammation of the pulmonary interstitium, with chronic obstructive pulmonary disease reported to be more prevalent in persons' exposed to airborne particles like cement, thereby worsening the increasing global public health burden (Chen, Dargahi, & Sorelli, 2025).

Inhalational injuries tend to be more common in less developed nations where the training and the use of PPE are less common, as found in this study (Sehsah *et al.*, 2020). Crystalline silica-induced pulmonary inflammation can progress to pulmonary fibrosis and pulmonary hypertension (Yazaki *et al.*, 2021). Additionally, chromium-induced oxidative stress releases free radicals, reactive oxygen species, and other cytokines. The higher incidence of hyperacute and acute irritative eye and pulmonary symptoms amongst the cement workers could be attributed to chromium, nickel, and cobalt as constituents of cement (Elhosary *et al.*, 2014). The respiratory pattern of cement-associated disorders could be related to the work schedule, as post-shift pulmonary function test can be associated with worsening of respiratory symptoms compared to other timings (Rahmani, *et al.*, 2018). Acute pathologic manifestations would be associated with increased cellular permeability, fluid extravasation, and edema formation, leading to obstructive diseases. The acute pathologic state is reported to be associated with allergy, and various levels of bronchoconstriction and spasms could manifest as dyspnea (Yes *et al.*, 2011). Stasis can lead to higher tendencies for respiratory tract infections,

increased secretion of IgE, evidenced by the high incidence of eosinophilia in the cement workers compared with the general population (Gamez, 2015). Constituents of cement have been implicated as risk factors and/or precipitants of almost any respiratory tract disease, including asthma, chronic bronchitis, lung cancer, tuberculosis, pneumonias, in addition to several conditions with restrictive respiratory patterns (Richard *et al.*, 2016).

The haematologic profile in the cement workers mirrors findings from a study conducted in our clime, which positively correlated the chronicity of exposure to cement with the leucocyte, neutrophil, and eosinophil counts (Meo *et al.*, 2002). Various pathologic mechanisms have been implicated in the development of anemia in cement workers. Though, this study didn't study haematologic morphology changes, the reported chromium-induced lymphopenia and hypo-proliferative anemia (from its lymphocytic and erythrocytic penetration could have led to the lymphopenia and anemia seen in this study (Cao *et al.*, 2018; Mojiminiyi *et al.*, 2008). Leukocytosis in the cement workers mirrors previous findings, with leukocytosis-associated neutrophilia that could suggest an immunologic response (Ahmad *et al.*, 2024). Anemia could also be attributed to inflammation-induced hemolysis, similar to previous findings on rats from a previous study at two cement manufacturing sites in Nigeria, were prominently those of leukocytosis and anemia (Ahmad *et al.*, 2024).

The increased tearing (lacrimation) mirrors previous findings of cement-related declining visual acuity resulting from protracted exposures, but which often presents with non-alarming symptoms, particularly during initial exposures (Dua *et al.*, 2020). In resource-challenged settings like Nigeria and some developing countries, a negative impact of cement use is the worsening socioeconomic, health, and psychosocial profile, particularly within the lower strata, and those in the middle and upper socioeconomic classes (Chung *et al.*, 2007). The non-availability or impaired capacity to work, in this population group, could have profound negative consequences on the economic and industrial growth in RCSs, considering the reported toxicity of cement chemicals on tissues/organs like the skin, liver, and the kidneys (Tungu *et al.*, 2015). The fact that most of these manual labourers are without health insurance coverage compared to the more-educated administrative staff further highlights the likely overwhelming negative psychosocial and health effects of exposure to cement (Snashall, 2007).

The fact that the composition of cement is based on the manufacturing company could create a two-fold beneficial avenues: one, industry site-based

assessment of contents would enable a deeper knowledge of specific features of each chemical, secondly, a follow-up program can help in setting baseline composition limits based on the toxicity levels and health burden of each chemical component of cement (Orgheipour *et al.*, 2020).

This study been a cross-sectional study, a causal relationship couldn't be determined. The specific health-related impact of each heavy metal in cement could not be assessed on account of cost. Many chemical markers of disease that could have suggested a causal relationship, such as IgE, serum erythropoietin, ferritin, iron, and peripheral blood film microcytosis, could not be determined due to the high financial burden. The all-male population hindered the determination of gender-based associations. Since episodes and duration of time-off periods could not be effectively determined, daily assays and recording of measures could not be reliable measures. The inability to determine the association between each heavy metal and inhalational and hematologic injuries limited the ability to assess the role of cofounders.

Therefore, the government and owners of cement factories and construction giants should collaborate on funding insurers' programmes for cement workers. Governments, owners of cement companies, and their employees should be well acquainted with research findings for effective education and planning purposes, which should be geared towards instituting preventive measures. Lowering the concentration of the harmful

chemicals while maintaining the quality of cement should be considered. Education and informative programs should be organized to sensitize the general population to the effects of cement on health. Periodic medical reviews, iron supplementation (when needed), and training in the use of the PPEs should be conducted to identify and treat cement-related diseases. Future studies should involve multiple cement factories and construction sites to enable a more comprehensive assessment of the dose-effect relationship of each chemical with disease symptoms and outcome, since chemical volume is mostly facility-dependent.

CONCLUSION

Exposure to cement is associated with respiratory and haematologic derangements and this has heightened medical and consequently psychosocial derangements among cement workers. The cement workers had longer working hours and higher frequencies of respiratory disorders, leukocytosis, anemia, and lymphopenia. The incidence of respiratory illnesses and the tendency not to treat was more common among the cement workers. This, coupled with lower socioeconomic status, further heightens the health burden and psychosocial stress of cement workers. The involvement of governments at all levels and cement industry owners in instituting health insurance coverage, training, and proper use of the PPE could significantly minimize and alleviate cement-related medical and psychosocial disabilities.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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