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Study of Uncontrolled Cement Dust Exposure and Its Prolonged Effects on Glycemic Status and Renal Function Markers among Male Cement Handlers at Dalmia Cement Factory

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KEYWORDS
Cement dust; Glycemic status; Diabetes mellitus; Renal function; Exposed; Unexposed; Environmental pollution

ABSTRACT: Environmental pollutants cause adverse impact on human body vital organs and ultimately leads to disease. It is of utmost importance to recognize those components or risk factors within individual's surrounding that are associated with it. The current study has explored the persisting effects of cement dust on glycemic status and selected renal function markers between male cement handlers at Dalmia Cement Factory. This study revealed that prolonged and recurrent exposures, contingent on the length of time and sensitivity of factory workers exposed to cement dust particles, have caused deleterious complications and deteriorating health conditions particularly seen in their glycemic status and selected renal function markers. The finding results of this investigation demonstrated that uncontrolled cement dust- exposure causes significant commonness of type 2 diabetes mellitus (T2DM), prediabetes and derailed renal function markers among cement handlers (CH). The levels of HbA1c, 24 hours urinary sugar, blood urea, creatinine, bi-carbonate and serum electrolytes (Na^+ and K^+) is significantly increased in cement handlers as compared to non-cement handlers (NCH) as controls. In addition to this significant difference was recorded in the blood pressure levels among exposed group when compared with control subjects at Dalmia Cement Factory. The hyperglycemic and nephrotoxic consequences of cement dust and its potential for development of insulin resistance, T2DM disease and renal insufficiency might exacerbate if the exposure to cement dust among cement handlers is not controlled.

INTRODUCTION

Environmental pollution has always been a major cause of unbearable numerous health-related complications. In this vista the cement industry is significant, and it is a rapid expansion all over the world and in India. Demand has been increases in the emerging market as a result of sustained levels of construction development activity for cement [1-3]. Cement industries are a source of environmental pollution [4]. Dust and airborne particulate are released in the different phases of cement production consisting of rotating kilns, storage and packing facilities, clinker cooling, and grinding of raw materials [5-6]. Numerous carcinogens, such as crystalline silica and hexavalent chromium, are found in cement dust. These elements may have detrimental impacts on several physiological organs [7]. Particles of cement dust can enter the body from skin contact, inhalation, and to a lesser degree ingestion. Cement dust has crystalline silica as a component [8] which is responsible for silicosis, Chronic Respiratory Pulmonary Disease (COPD), pulmonary tuberculosis, rheumatoid artheritis. Its chronic exposure results in kidney damage [9-11]. Repeated exposure to Cr(VI) compounds lead to anomalies in hematological parameters [12]. Cement dust exposure is still a concerning issue that worsens respiratory conditions and increases the possibility of coronary artery disease (CAD) [13-14]. Insulin resistance, glucose metabolic dysfunction, and non-insulin dependent diabetes mellitus (NIDDM) or Type 2 diabetes mellitus (T2DM) are often observed in industrial cement workers who are exposed to cement dust on a regular basis.

According to reports from experiments, infiltration of cement dust in the different tissues especially lungs, pancreas, kidney and liver ultimately affect their cellular structure leading to damage of membrane components through the process of lipid peroxidation. The loss in membrane integrity has been connected to leaking of essential cellular components. Consequently an increase in enzyme activities and plasma concentration of proteins can give a hint for an early identification of organ failure brought on by unmanaged

Journal of Chemical Health Risks

www.jchr.org

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cement dust exposure [15-16]. Toxic cement dust also harm to many bodily organs due to inflammation. WBCs or white blood cells with its differentials (inflammatory markers) are thought to be biological indicators of persistent tissue inflammation in workers of cement industry.

OBJECTIVES

Given that to the best of our knowledge, this is the first study done in Bihar state of India (Dalmia Cement Factory at Kalyanpur, Banjari, Bihar) exploring air pollution and environmental health issues among cement factory workers and to investigate the correlation between repeated cement dust exposure and prevalence of prediabetes and type 2 diabetes mellitus along with nephropathy as the major late complication of diabetes mellitus.

Studies are available on cement dust and diabetes mellitus, pulmonary disease, kidney function tests (KFTs), liver function tests(LFTs), hematological and inflammatory markers but most of these were conducted without considering long term duration-response effect with exposed workers age correlation. However, the present study revealed the occurrence of disease and impairment of organ functions markedly associated with duration of exposure to cement dust and age of cement handlers (study period between August 2015 to September 2023).

We believe that the findings of present research article will appeal to the readership of Journal of Chemical Health Risks.

MATERIAL AND METHODS

The sum of 120 participants comprising 60 having a background in prolonged repeated exposure to the cement dust using their employment or occupation from the last about 8 years designated as cement dust exposed workers or cement handlers (CH) and another 60 unexposed to cement dust workers or non- cement handlers (NCH) among office staff in the same factory as control groups at Dalmia Cement Factory at Kalyanpur, Banjari, Bihar-821303, India. The mean age of workers was 36.51±1.15 years, mean Body Mass Index was 22.40±2.38 m/kg^2 and average time frame of work in cement's industry was 94.15±3.85 months with 8 hours of cement dust exposure daily for six days a week. To evaluate the glycemic status and selected renal function markers in cement handlers and non-cement handlers subject, blood (2-3 ml) samples using a vein-puncture method was collected during fasting state between 7 am to 9 am each in heparin-anticoagulant and EDTA (Ethylene Diamine Tetraacetic Acid) containing tubes and entire 24 hours urine was collected in special sterile Urine GUARD containers (refrigerated during and after collection) by paramedical staff at Dalmia Cement Factory and sent right away to the biochemistry lab. HbA1c or glycated haemoglobin was analysed by Dimension Xpand analyser make of Siemens. The sugar content present in 24 hours urine was estimated by automated urine analyser make of Biosenseuchek 4.0.2 ENC, India. Key parameters of renal function tests (RFTs) was analysed in fully automated Turbochem 100 chemistry analyser make of CPC diagnostics, USA. Bicarbonate was estimated by fully automated $HCO3^-$ analyser make of HDC India Limited. Serum electrolytes were determined using ion-selective electrode method by fully automated Easylyte analyser make of Transasia, Germany. Blood pressure was monitored by Diamond BPMR 120 Deluxe Mercurial Type BP Instrument.

Exclusion criteria

Workers in the cement industry who have a history of known blood transfusion, consumers of alcohol, cigarette and shisha smoking, anemia, asthma, or a family history of the diabetes disease, malignancy were excluded.

Cement Workers with BMI more than 30 m/kg2 excluded in order to reduce the effect of obesity on the incidence of type 2 diabetes and pre-diabetes. Any workers who have previously worked in any other industry that produces fumes or dust were also not included in this study.

Ethical clearance

The current research carried out harmoniously with the "1964 Declaration of Helsinki" and any updates made thereafter, or similar moral guidelines and the protocol was duly approved by Ethical Committee and Review Board, Department Research and Development, Chandigarh University, Chandigarh[Reference No.:DRB-PUC/ECRB/2015/16.] Prior approval was taken by management authority of Dalmia Cement Factory at Kalyanpur, Banjari, Bihar. All participants received an explanation of the study's purpose. Each of them freely participated in the study and completed a written informed permission form. Participants were given the assurance by researchers that their personal information would be kept private, and coding was completed.

Statistical analysis

Every data analysis was completed by using student's paired t-test statistically and analysis of variance (ANOVA) to compare the two groups using paired data with varying degrees of significance. Mean ± S.E was used to express the data of determinations. A statistically significant probability value ($p < 0.05$) was considered.

Data collection

This is case-control research; Face-to-face interviews were used to gather the information from workers, which were produced in both English and the workers' native tongue. The workers who fulfilled the inclusion criteria were told about the

Journal of Chemical Health Risks

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JCHR (2023) 13(6), 1090-1095 | ISSN:2251-6727

study's aims and provided written, signed informed consent. After that, they provided the information required to complete the questionnaire. The group study (cement handlers) at Dalmia Cement Factory included those who worked in activities including bagging, loading, grinding, and crushing that produced the greatest amount of cement dust in their immediate environment [17].

RESULTS

Anthropometric indices (Weight, Height, and Body Mass Index), Mean age of non-cement handlers (NCH) designated as control groups and cement dust exposed cement handlers(CH) designated as test groups were as seen in Table 1.

Table 1. The sociodemographic features of Dalmia Cement Factory's non-cement handlers (NCH) and cement handlers (CH) who are exposed to cement dust (n = 120).

Variables	NCH (Range) (n=60)	CH (Range) (n=60)	P - Value
Age (Years)	33.78 ± 0.98 (20.0 - 45.0)	39.24 ± 1.32 (25.0 – 48.0)	< 0.05*
Weight (Kg)	61.75 ± 4.20 (50.0 – 71.0)	61.08 ± 5.5 (52.0 – 70.0)	> 0.05
Height (Cm)	163.20 ± 7.21 (145.0 – 180.0)	168.1 ± 5.78 (149.0 – 177.0)	< 0.05*
BMI (m/Kg2)	23.20 ± 2.11 (19.5 – 25.5)	21.60 ± 2.56 (19.0 – 25.2)	< 0.05*

Note: *Significant at p less than 0.05, **Significant at p less than 0.01; values are given as Mean ± S.E.
Abbreviation:BMI =Body Mass Index

Based on the 2018 ADA requirements, three types of cement manufacturing workers were identified. (HbA1c < 5.7%) non diabetics, (HbA1c 5.7% - 6.4%) prediabetics and (HbA1c > 6.4%) diabetics. Out of 60 participants (cement handlers) about 24 (41.66%) were found to be non diabetics, 12 (16.66%) prediabetics and 24 (41.66%) diabetics. The mean's values of HbA1c among non-diabetic, prediabetics and diabetics were 5.39 ± 0.46%, 6.11 ± 1.39% and 7.25 ± 2.02% respectively. The mean value of 24 hours urinary sugar among non-diabetics, pre-diabetics and diabetics were 0.10 ± 0.02 g/24hrs, 0.30 ± 0.06 g/24hrs and 0.55 ± 0.09 g/24hrs respectively. The data are seen as in Table 2.

Table 2. Occurring stage of pre-diabetes and Type-2 diabetes mellitus or NIDDM on glycemic status among cement dust exposed cement handlers (CH) with different durations of exposure to cement dust at Dalmia Cement Factory (n = 60).

Differentials	Non diabetics (n=24)	Prediabetics (n=12)	Diabetics (n=24)	P - Value
Parameters	**HbA1c < 5 %**	**HbA1c (5.7 – 6.4) %**	**HbA1c >6.4 %**	
HbA1c (%)	5.39 ± 046	6.21 ± .015	8.25 ± 1.02	< 0.05*
Urinary Sugar (g/24 hrs)	0.10 ± 0.02 (< 0.15)	0.30 ± 0.06	0.55 ± 0.09	< 0.05*
Age (Years)	33.78 ± .0.98	37.15 ± 1.79	39.24 ± 1.32	< 0.05*
Exposure to cement dust (Months)	66.46 ± 3.54	73.42 ± 1.42	94.15 ± 3.85	< 0.05*

Note: *Significant at p less than 0.05, **Significant at p less than 0.01; values are given as Mean ± S.E
HbA1c are shown as a frequency (%). The classification of pre-diabetes and diabetes mellitus was done using the American Diabetes

Journal of Chemical Health Risks

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Association's [2018] HbA1c guidelines
Abbreviation: Glycated haemoglobin is known as HbA1c, while non-insulin dependent diabetes mellitus is known as NIDDM.

In order to assess long term exposer of cement dust among cement handlers on their renal function and blood pressure, key parameters of renal function tests (RFTs) were analysed in blood samples of both, cement dust-exposed and unexposed workers. Our result revealed considerable increase ($P < 0.05$) in the concentration of urea, creatinine, serum electrolytes (Na^+ and K^+) and bicarbonate levels in the blood samples of cement handlers in contrast to their equivalent non-cement handlers (controls). Thus, the present study shows derailed kidney function and electrolyte imbalance in cement handlers when compared to control subjects. The data are seen as in Table 3.

Table 3. Impact of exposure of cement dirt on tests on renal function (RFTs) among non cement handlers (NCH) and cement dust exposed CH with different durations of exposure to cement dust at Dalmia Cement Factory.

Parameters	NCH (Range) (n=60)	CH (Range) (n=60)	P - Value
Serum Creatinine (mg/dl)	1.10 ± 008 (0.7 - 1.4)	2.00 ± 0.09	< 0.01**
Urea (mg/dl)	32.20 ± 0.37 (14.9 – 38.5)	72.54 ± 1.00	< 0.05*
Na^+(Mmol/l)	140.05 ± 4.95 (135 – 155)	163.32 ± 3.99	< 0.05*
K^+(Mmol/l)	4.40 ± 0.36 (3.5 – 5.5)	9.50 ± 1.49	< 0.05*
HCO_3^-(Mmol/l)	24.15 ± 0.35 (22 – 29)	39.46 ± 0.54	< 0.05*
SBP (mm of Hg)	119.83 ± 3.16 (100 – 130)	130.87 ± 3.72	< 0.05*
DBP (mm of Hg)	79.40 ± 2.80 (70 – 90)	96.50 ± 2.77	< 0.05*

Note: *Significant at p less than 0.05, **Significant at p less than 0.01; values are given as Mean ± S.E
Abbreviation: Electrolytes with the symbols Na+, K+, and $HCO3^-$ are sodium, potassium, and bicarbonate, respectively. CH=cemet handler
Systolic blood pressure is known as SBP and diastolic blood pressure as DBP

DISCUSSION

Previously only associated with wealth and sedentary lifestyles, diabetes has become the most common metabolic illness worldwide in recent times, with its incidence rising rapidly across all societal segments [18]. Instead of latest treatment methods and despite tremendous developments in the medical sciences, Diabetes is still a chronic incurable disease [19]. Diabetes mellitus particularly Type 2 (NIDDM) is the major version because of its high frequency, long duration and numerous unbearable complication [20].Particularly nephropathy, retinopathy, cardio-vascular, hepatocellular, pulmonary and hematological disorders [21].

To the extent of our understanding, It is the first study done in Bihar state of India exploring air pollution and environmental health issues among cement handlers factory workers and to investigate the correlation between work place exposure of cement dust among cement handlers and the frequency of type 2 diabetes mellitus and pre-diabetes along with nephropathy as its major late complication. A positive association was found in the current investigation that shows that

Journal of Chemical Health Risks

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JCHR (2023) 13(6), 1090-1095 | ISSN:2251-6727

environmental contamination which has been on the rise recently acting as causative agent of T2DM. The research demonstrates cement dust contamination possibly causes insulin resistance and eventually causes T2DM significantly (P <0.05). Previous studies also identified that prolonged exposure of higher concentration of environmental dust (the primary cause of the development of insulin resistance) is air pollution and T2DM [22-23]. In a similar vein, a different study found that the length of time plastic industry workers were exposed to the same workplace elevated frequency of type 2 diabetes and pre-diabetes [24]. The present study exhibits the incidence of T2DM (also called adult onset diabetes) and prediabetes among cement dust exposed cement handlers at Dalmia Cement Factory. This metabolic disease increased with duration of cement dust exposure and age of cement factory workers. In addition significant association (P> 0.05) was found between the BMI and occurrence of type 2 diabetes mellitus (T2DM) and prediabetes. It displays the influence of exposure to cement dust on Body Mass Index (BMI).

The regular breakdown of muscle cells during exercise results in the waste product creatinine being produced in the blood. Blood creatinine levels rise when renal function is compromised. An indicator that the kidneys are not functioning at their best, maybe due to environmental toxins, is a little rise of the creatinine level over the usual range. The exposure of silica- a constituent of cement dust was described as being associated with renal insufficiency [25]. All around the body blood contain proteins. Urea is the waste product that remains after a body cell uses the proteins and returns to the circulation. Healthy kidneys remove urea from blood, however if it isn't functioning all right, the amount of urea rises in the blood. Our results show the increase of urea in cement handlers which perhaps as a result of kidney unwillingness to extract them from the blood. Between exposed and unexposed conditions, the values of Na+ and K+ demonstrate notable difference (P < 0.05). Because of this cement dust imbalance of ion levels occur in the body. Our results show significant elevation (P <0.05) of serum electrolytes in cement dust exposed cement handlers. In a similar study the slight elevation of electrolytes have been shown due to relative hemoconcentration the exposed group as a result of mild de-hydration and stress [26]. Our result revealed increase in the level of HCO_3^- in the exposed group. It is noticeably different in elevation (P< 0.05) compared to the group exposed to cement dust and the personnel who were not exposed. Similarly finding was obtained in earlier study [27]. This might be caused by the pressure from the high concentration of alkali oxides, and other metals namely: oxides of calcium, iron and silicon, aluminium trioxide and magnesium in cement [28]. Studies are available on cement dust and diabetes mellitus, lung, kidney function tests (KFTs) but the majority of them were done without taking the long-term duration response impact into account with exposed workers age correlation on respiratory, kidney impairment [29]. However present study revealed that the prolonged exposure of cement dust have caused pre-diabetes, type 2 diabetes mellitus along with impairment of renal function among cement dust exposed cement handlers when compared with control subjects at Dalmia cement factory in Bihar, India.

CONCLUSION

This work adds to the body of evidence showing prolonged exposure to cement dust was linked to significant occurrence of pre-diabetes and NIDDM or T2DM, adversely affect the diabetes ethology and have impaired renal function among cement dust exposed cement handlers at Dalmia Cement Factory. It also revealed the occurrence of disease and impairment of organs are connected with the length of time cement handlers were exposed to cement dust and their age. The outcomes results are of utmost relevance because it emphasizes the necessity of mitigating the negative health impacts of cement operator's prolonged exposure to cement dust. The hyperglycemic and renal toxic cement dust's effects and potential for developing auto immune disease may have intensified if the cement dust exposure is unregulated. Thus, it is advised that the government, employees, and supervisory of cement factories collaborate to implement technological preventative measures such a well-ventilated work place, Employees should be provided with regular medical examinations, wear the proper apron, mask, safety goggles, gloves, and earplugs, and get health education about personal protective actions, but need support in the form of on-going educational initiatives and governmental [30].

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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