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Respiratory symptoms and dust exposure among cement processing factory workers, Tanzania

Abstract

Background: Cement manufacturing is among the growing industry in Tanzania. It involves processes from blending, kiln burning, clinker, grinding and cement final production. All of these cement manufacturing processes generates cement dust which contain silica and other toxic materials which can potentially affect respiratory system of exposed workers.

Methods: This cross sectional comparative study design was conducted at cement processing factory and Ndanda mineral water processing factory as control, all of these factories are located in Mtwara region in Tanzania. A total of 398 workers were selected randomly from these two factories. Data were collected using structured questionnaires for respiratory health symptoms, Checklists was used for the observational parameters. Dust sampling was done using Side Kick Casella (SKC) pumps and PVC filter on IOM cassettes was used to determine dust exposures. The analysis was done by SPSS program vers 20. The significant association between the dependent variable and the factors was registered when Pvalue was less the 0.05.

Results: Packing and cleaner were the sections with higher total cement dust concentrations above Occupational Exposure Limit which were 33.24 and 15.39 mg/m^3 respectively. Workers in cement processing factory were exposed to higher levels of total dust with AM 14.1033 mg/m^3 (SD 4.357) than in mineral water processing factory AM 0.0867 mg/m3 (SD 0.035). The Prevalence of respiratory symptoms was higher among workers in cement processing factory (45.7%) than in mineral water processing factory (25%), this was statistically significant.

Conclusion: Exposure to cement dust in a working environment causes the increase in work related respiratory symptoms and reduced lung function. A control measure to decrease the dust exposure level among cement workers in line with periodic medical examination is highly needed.

Keywords: cement dust, exposure, respiratory symptoms, Tanzania

Volume 11 Issue 1 - 2022

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Received: October 07, 2021 | **Published:** April 19, 2022

Introduction

Cement factories represent one of the most important basic elements in the economic development of any country. Workers in this sector constitute an important productive aggregate in the community. Cement is one of the most important building materials in the world.[1] Cement is a mixture of Calcium oxide (CaO) (62–66%), Silicon oxide (SiO2) (19–22%), Aluminum tri-oxide (Al2O3) (4–8%), Ferric oxide (Fe2O3) (2–5%), Magnesium oxide (MgO) (1–2%) and small fraction of Selenium. The aerodynamic diameter of cement particles range from 0.05 to 5.0 µm. These particles are respirable in size, hence most of brands of cement are as important as potential cause of occupational lung disease.[2]

Worker's exposure to total dust should not exceed 10mg/m^3 as TWA for eight-hour work day and 40-hr work week.[3] Dust with aero diameter of less 100µm is inhalable. Inhalation is the primary route of dust exposure where by these agents gain access to respiratory system and can potentially affect exposed workers causing respiratory problems.[4] Globally occupational respiratory diseases are huge which account for up to 17% of all registered work-related diseases and the burden is highly affecting developing countries. Africa contributes about 11.8% to the global work related mortality, and it is estimated that 2.78 million deaths occurring annually across the countries being attributed to work.[5]

In developed nations like Great Britain there are currently about 12,000 deaths each year due to occupational respiratory diseases, about 2/3 of which were due to dust related diseases.[6] In developing countries like India, the second cement producing country, respiratory disease accounted for 17% of the 11 million occupational diseases and chronic obstructive pulmonary diseases are responsible for 87 % of work related respiratory disease mortality.[7] In Tanzania, respiratory diseases are among the top ten causes of deaths in the country, where by COPD and lower respiratory infections accounts for 6 % and 5% of mortality respectively.[9] The current study assessed the cement dust exposure and the respiratory health symptoms in relation to job categories in comparative to water processing factory in Tanzania.

Material and methods

Study design and setting

The study design was a cross sectional comparative study undertaken to assess respiratory symptoms and dust exposure among cement processing factory workers(exposed group) and Ndanda mineral water processing (non exposed group)in Mtwara Tanzania.

Participants

Study participants were workers working in cement dust prone sections which are the clinker production, material processing, filtering, package and loading and cleaning at the Cement processing factory and workers at Ndanda mineral water processing factory where by all factories are located in Mtwara.

Data collection

Data on respiratory symptoms were collected by using a structured questionnaire adapted from a modified version of the British Medical

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Research Council questionnaire on respiratory symptoms. These tools were constructed in English and translated into Swahili and again back to English language.

Personal total dust measurements were collected from the selected study participants in cement and mineral water processing factories as control. The personal total dust samples were collected on pre-weighed PVC filter membranes of 0.8 micrometer (µm) pore size placed in a closed face 37-mm IOM filter cassette connected to Side Kick Casella (SKC) pumps. The pumps were operated and calibrated at a flow rate of 2.0 L/minutes.

Data on the use of Personal Protective Equipment in working environment were collected by using a structured question and observation. A walk through survey was conducted guided with observation check list which assessed the working environment.

Data analysis

Prevalence of respiratory symptoms among workers in cement factory who are exposed group and workers in water factory serving as unexposed group were computed. Chi-square (χ^2) test was used to compare percentages of respiratory symptoms of these groups. The predictors included dust exposure levels in mg/ m^3, smoking habit (yes=1, no=0), years of work, and age. A p-value of less than 0.05 and 95% CI were considered statistically significant for the associations between depend variable and independent variables.

Ethical consideration

Ethical clearance was obtained from Muhimbili University of Health and Allied Sciences Research and publication directorate as well as Ethical committee review board. Permission to conduct this study was obtained from a Cement processing factory as well as Ndanda mineral water processing factory in Mtwara. Informed consent was sought from study participants after the aims and objectives of the study clearly explained to them.

Results

Socio-demographic characteristics of workers in cement processing and mineral water processing factories

A total of 398 workers were included in this study. 298 workers were from cement factory and 100 workers were from natural mineral water processing factory. In cement processing factory there were 86.58% male and 13.42% female while in control there were 18% male and 82% female. The mean age and standard deviation of the study population were 30.3(4.7) cement and 29.2(11.8) in water processing factory. In cement processing factory job categories there were 9.43% workers in repair and maintenance, 24.92% in clinker, 28.96% in packing, 19.8% in loading and 16.84% in cleaner. Regarding past dust job exposure there were 14.43% of workers in cement processing factory who reported past job dust exposure Table 1.

Table 1 Socio-demographic characteristics of workers in cement and mineral water processing factories

Parameter	Cement workers n = 298	Water workers n = 100	Total n = 398
Sex			
Male	258 (86.6%)	18 (18%)	276 (69.4%)
Female	40 (13.4%)	82 (82%)	122 (30.7%)
Age category			
< 30 Years	162 (54.4%)	59 (59%)	222 (55.6%)
30+ Years	136 (45.6%)	41 (41%)	176 (44.4%)
Education level			
None	12 (4%)	0 (0%)	12 (3%)
Primary	114 (38.3%)	56 (56%)	170 (42.7%)
Secondary	103 (34.6%)	44 (44%)	147 (36.9%)
College (Tertiary)	69 (23.2%)	0 (0%)	69 (17.3%)
Job category			
Repair& Maintenance	28 (9.4%)		28 (7.1%)
Clinker	74 (24.9%)		74 (18.6%)
Packing	86 (29%)		86 (21.7%)
Loading	60 (19.9%)		60 (14.9%)
Cleaner	50 (16.8%)		50 (12.6%)
Other (Controls)		100 (100%)	100 (26%)
For how long in job			
1 Year	76 (25.5%)	0 (0%)	76 (19.1%)
2 Years	139 (46.6%)	58 (58%)	197 (49.5%)
3 Years	66 (22.2%)	42 (42%)	108 (27.1%)
4 Years	17 (5.7%)	0 (0%)	17 (4.3%)

Citation: Mamuya SH, Sabuni EC. Respiratory symptoms and dust exposure among cement processing factory workers, Tanzania. *MOJ Public Health.* 2022;11(1):43–48. DOI: 10.15406/mojph.2022.11.00373

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Table Continued...

Parameter	Cement workers n = 298	Water workers n = 100	Total n = 398
Smoking habit			
Smokers	48 (16.1%)	4 (4%)	52 (13.1%)
Nonsmokers	250 (83.9%)	96 (96%)	346 (87%)
Past dust exposure			
Past exposed	43 (14.4%)	0 (0%)	43 (10.8%)
Past not expose	255 (85.6%)	100 (100%)	355 (89.2%)
Mean (SD)			
Age [Years]	30.3 (4.7)	29.2 (11.8)	29.8 (8.3)
Weight [Kg]	66.3 (8.6)	61 (5.3)	63.7 (7)
Height [cm]	164.6 (6.9)	160.9 (5.8)	162.8 (6.3)

Respiratory symptoms by gender

Respiratory symptoms by gender showed more proportion of male workers was affected compare the female workers. The significant differences were noted for reported cough day and night (pvalue =0.0001) and cough for 4 to 6 times a day in a week (pvalue =0.017) Table 2.

Table 2 Distribution of reported respiratory symptom by gender to among selected workers

Respiratory symptoms	Status	Male	Female	Total	P-value
Cough in the morning?	No	188(69.4%)	92(75.4%)	280(71.2%)	0.135
	YES	83(30.6%)	30(24.6%)	113(28.8%)	
Coughing day and night	No	214(77.5%)	115(95.0%)	329(82.9%)	0
	Yes	62(22.5%)	6(5.0%)	68(17.1%)	
Cough 4-6 times a day in a week	No	264(96%)	122(100%)	386(97.2%)	0.017
	Yes	11(4.0%)	0(0%)	11(2.8%)	
Cough for more than three months	No	267(96.7%)	122(100%)	389(97.7%)	0.036
	Yes	9(3.3%)	0(0%)	9(2.3%)	
Cough with phlegm production	No	273(98.9%)	120(99.2%)	393(99.0%	0.648
	Yes	3(1.1%)	1(0.8%)	4(1.0%)	
Cough with phlegm production in day and night	No	272(98.6%)	122(100%)	394(99.0%)	0.23
	Yes	4(1.4%)	0(0.0%)	4(1.0%)	

Respiratory symptoms and job category among workers in cement and mineral water processing factories

The relationship between respiratory symptoms and job category of cement and mineral water processing factories showed workers in job categories with high cement dust exposure had higher respiratory symptoms than those working in low cement dust exposure. The findings associations are statically significant ($p<0.05$). The workers who are working in packing , loading and cleaning had higher prevalence of respiratory symptoms than those who are working in repair and maintenance section ($p<0.05$). The distribution of respiratory symptoms by job categories and control group showed higher respiratory symptoms to among cement job categories compared to control group and the different were significantly statistically different with all symptoms except cough with phlegm production symptoms Table 3. Cleaning and packing workers reported more symptoms in coughing in the morning 43.8% and 40.7% respectively while among control workers 25% reported cough in the morning Table 4.

Respiratory symptoms and smoking status

Distribution of respiratory symptoms by smoking status showed that smoker reported more respiratory symptoms compared to non-smokers for cough in the morning and coughing in day and night with P value of 0.008 and 0.0001 respectively Table 5.

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Table 3 Distribution of reported respiratory symptom by Job category to among exposed and control workers

	Status	Maintenance Repair	Clinker	Packing	Loading	Cleaning	Control	P-value
Cough in the morning?	No	21(77.8%)	59(79.7%)	51(59.3%)	46(80.7%)	27(66.2%)	75(75%)	0.004
	YES	6(22.2%)	15(20.3%)	35(40.7%)	11(19.3%)	21(43.8%)	25(25%)	
Coughing day and night	No	27(96.4%)	60(81.1%)	53(61.6%)	49(83.1%)	40(80.0%)	99(100%)	0
	Yes	1(3.6%)	14(8.3%)	33(38.4%)	10(16.9%)	10(20.0%)	0(0%)	
Cough 4-6 times a day in a week	No	28(100%)	72(97.3%)	86(100%)	51(87.9%)	48(96.0%)	100(100%)	0.001
	Yes	0(0.0%)	2(2.7%)	0(0%)	7(12.1%)	2(4%)	0(0%)	
Cough for more than three months	No	28(100%)	72(97.3%)	86(100%)	53(89.9%)	49(98%)	100(100%)	0.036
	Yes	0(0%)	2(2.7%)	0(0.0%)	6(10.2%)	1(2.0%)	0(0%)	
Cough with phlegm production	No	27(96.4%)	73(100%)	86(100%)	58(98.3%)	100(100%)	0.1	0.648
	Yes	1(3.6%)	0(0%)	0(0%)	1(1.7%)	2(4%)	0(0%)	

Table 4 Distribution of respiratory symptoms by smoking status of the study population

	Status	Non Smokers No	Smoking	Total	P-value
Cough in the morning?	No	252(73.3%)	25(54.3%)	277(71.0%	0.008
	YES	92(26.7%)	21(45.7%)	113(29.0.3%)	
Coughing day and night	No	297(85.6%)	29(61.7%)	326(82.9%)	0
	Yes	50(14.4%)	18(38.3%)	68(17.1%)	
Cough 4-6 times a day in a week	No	337(97.1%)	46(97.9%)	326(82.7%)	0.615
	Yes	10(2.9%)	1(2.1%)	11(2.8%)	
Cough for more than three months	No	240(97.7%)	46(97.9%)	386(97.7%)	0.709
	Yes	8(2.3%)	1(2.1%)	9(2.3%)	
Cough with phlegm production	No	345(99.4%)	45(95.7%)	390(99.0%	0.071
	Yes	2(0.6%)	2(4.3%)	4(1.0%)	
Cough with phlegm production in day and night	No	294(98.7%)	100(100%)	394(99.0%)	0.23
	Yes	4(1.3%)	0(0.0%)	4(1.0%)	
Phlegm production as 4-6 times a day for 4 or more days a week	No	346(99.1%	45(95.7%)	390(98.7%)	0.11
	Yes	3(0.9%)	2(4.3%	5(1.3%)	

Table 5 The average dust exposure concentration between workers in cement processing and mineral water processing factories

Factory	Number of dust sample taken	Average Arithmetic Mean (AM)	Standard Deviation (SD)
Cement processing	12	14.1	4.36
Water processing	3	0.08	0.04

Dust exposure status

Higher dust exposure concentrations above the threshold value were observed among cement workers 14.10 mg/m^3 than in the control group 0.08mg/m^3.

Personal dust exposure levels between similar exposure groups

The workers of cement processing factory were divided into four similar exposure groups according to jobs they perform (sections).

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These were Clinker, Packing, Loading and Cleaner. Packing and cleaner were the sections with higher total cement dust concentration which demonstrated above Occupational Exposure Limit 33.24 and 15.39 respectively Table 6. The dust sample taken from Packing and loading all were above the Threshold limit set by American Committee for Government Industrial Hygienist of 10mg/m^3.

Table 6 Personal total cement dust samples among similar exposure groups (sections) in cement processing factory

Similar exposure group (sections)	Number of cement dust sample taken	Arithmetic Mean (AM) mg/m3	Standard Deviation (SD mg/m3)	Number of dust samples exceeding 10 mg/m3
Clinker	3	1.63	1.35	0
Packing	3	33.24	10.26	3
Loading	3	6.15	3.28	0
Cleaner	3	15.39	2.54	3

Discussion

Prevalence of respiratory symptoms was higher among workers in cement than mineral water processing factory (control), 45.7% and 25% respectively. These findings were higher than those in the study done in United Arab Emirate among cement factory workers[11] which reported prevalence of respiratory symptoms among exposed group; cough (19.5%), phlegm (14.8%), wheezing (2.0%), shortness of breath (4.7%), chronic bronchitis (16.0%) than in non-exposed group. The findings from this study was similar to the study done in North west Ethiopia among cement factory workers[18] whereby prevalence of respiratory symptoms were higher among cement workers (66.2%) than in controls (31.2%). Also the finding of this study was similar to the study done in Tanzania which showed that the prevalence of respiratory symptoms in cement plant workers in 2010 was higher compared with control.[13] The findings from this study showed similar findings other studies which reported higher prevalence of respiratory symptoms among workers in cement processing factory.[9,10,14–17]

The workers in cement processing factory were exposed to higher dust levels than controls. The mean concentration was (14.10mg/m^3) among workers in cement processing and (0.09mg/m^3) among the controls, the difference in exposure levels among the two groups was statistically significant $p<0.05$. 46% of workers in cement processing factory were exposed to total dust concentrations above the occupational exposure limits set by American Conference of Governmental Industrial Hygienist which is 10 mg/m^3.[3] The results in our study correlate with the study done in United Arab Emirate where the exposure concentration among workers in cement processing factory was high.[12] The average total dust concentration in some cement processing factories varied up to 120 mg/m^3 which are above Occupational Exposure Limit.[2,10,14,18,20]

The study is limited with the design being crosectional nature in which both the exposure and outcome were assessed at a single time. Even though the use of the control group for workers in water processing factory and the stratification by job category during analysis were the stronghold of the findings.

Conclusion

This study has demonstrated higher number of workers in cement processing factory experience respiratory health symptoms than workers in mineral water processing factory. This has revealed that high prevalence of respiratory symptoms among exposed workers might be associated with increased dust concentrations. Smokers reported more respiratory symptoms compared to non-smokers. Packing and cleaning workers reported more dust exposure and more respiratory health problems. Cement dust concentration among cement processing factory workers is high as most of the workers in the production sections were exposed to cement dust above exposure limits, hence the need for mask was necessary during the full shift. Nonsmoking sensation program should be sensitized so that workers encourage stopping smoking.

Availability of data and material

The data sets used and analyzed during the current study are available and still under analysis for subsequent publications but will be available upon request from authors.

Acknowledgments

Our special thanks to NORHED for their financial support which enables the study to be completed. Also, we acknowledge the Government Authority of Mtwara Region and District Executive Directors of Mtwara for permission to conduct the study. My gratitude to all cement manufacturing workers who participated in this study.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was funded by NORAD through the NORHED-programme (Norwegian Programme for Capacity Development in Higher Education and Research for Development), the funder supported financial support for field operation of the study, and the funder had no influence on the operation and analysis of the findings.

Authors' contributions

SHM and ECS designed the study, conducted data collection, did data analysis and interpretation of findings, wrote and approved the manuscript.

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