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by [Mwaiselage J](#), [Bråtveit M](#), [Moen BE](#), [Mashalla Y](#)

Affiliation: Section for Occupational Medicine, Faculty of Medicine, University of Bergen, Kalfarvei 31, N-5018 Bergen, Norway. jmwaiselage@yahoo.com

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Respiratory symptoms and chronic obstructive pulmonary disease among cement factory workers

by Julius Mwaiselage, MD,^{1,2} Magne Bråtveit, PhD,¹ Bente E Moen, PhD,¹ Yohana Mashalla, PhD³

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Objectives This study assessed chronic respiratory symptoms and chronic obstructive pulmonary disease (COPD) among workers exposed to cement dust at a Tanzanian cement factory.

Methods A total of 120 exposed workers and 107 controls participated in this cross-sectional investigation. Information on demographics, occupational history, chronic respiratory symptoms, smoking habits, and use of respiratory protection equipment was collected by questionnaire. Ventilatory function testing and measurement of personal total dust exposure were also carried out. COPD was diagnosed for workers with chronic bronchitis who also had spirometric airflow obstruction. Chronic respiratory symptoms and COPD were correlated with cumulative total dust exposure and adjusted for age, pack-years, and education.

Results The exposed workers had more chronic cough [odds ratio (OR) 4.5, 95% confidence interval (95% CI) 1.9–10.4], chronic sputum production (OR 10.8, 95% CI 4.4–26.4), dyspnea (OR 5.3, 95% CI 1.9–15.2), work-related shortness of breath (OR 4.8, 95% CI 1.6–14.2), and chronic bronchitis (OR 5.5, 95% CI 2.0–15.3) than the controls. Chronic cough, chronic sputum production, dyspnea, work-related shortness of breath, and chronic bronchitis were significantly related to cumulative dust exposure of 20.0–99.9 and ≥ 100.0 versus < 20.0 mg/m³-years. The prevalence of COPD was higher for the exposed group (18.8%) than for the controls (4.8%). The odds ratio for COPD was significantly increased for cumulative dust exposure, ≥ 100.0 versus < 20.0 mg/m³-years (OR 11.2, 95% CI 2.2–56.0).

Conclusions Cement workers seem to be at high risk of developing chronic respiratory symptoms and COPD, probably caused by cumulative total dust exposure independent of smoking habits.

Key terms cement worker; chronic respiratory symptom; cross-sectional study; cumulative total dust exposure; exposure–response relationship.

Cement is produced through a series of processes that includes quarrying, crushing, raw milling, blending, kiln burning to form clinker, cement milling, and packing. Substantial dust is emitted during these processes, exposing workers to dust.

Most previous studies have reported that exposed cement workers experience more respiratory symptoms than controls, (1–8), whereas a few studies have found no difference in most respiratory symptoms between exposed workers and controls (9–11). Most of these studies did not adjust for possible confounders such as age, duration of employment, and smoking when comparing the two groups (1–4, 7). Some studies have also

investigated the association between current dust exposure levels or categories (high, medium, low) and respiratory symptoms among cement workers, with differing results (6, 8–12). The exposure–response relationship between “cumulative” cement dust exposure and respiratory symptoms has not yet been investigated.

Although there is evidence of an increased prevalence of respiratory symptoms among exposed cement workers, the level of the risk of developing chronic obstructive pulmonary disease (COPD) has been uncertain, as only two such studies have been performed in the cement industry (11, 13). A study in Norway (11) found no difference in the prevalence of COPD between

¹ Section for Occupational Medicine, Institute of Public Health and Primary Health Care, Faculty of Medicine, University of Bergen, Bergen, Norway.

² Centre for International Health, Faculty of Medicine, University of Bergen, Bergen, Norway.

³ Department of Physiology, Faculty of Medicine, Muhimbili University College of Health Sciences, Dar Es Salaam, Tanzania.

Correspondence to: Dr Julius Mwaiselage, Section for Occupational Medicine, Faculty of Medicine, University of Bergen, Kalfarvei 31, N-5018 Bergen, Norway. [E-mail: jmwaiselage@yahoo.com]

former cement workers (14.3%) and blue-collar workers (14.0%). A longitudinal study in Denmark (13), based on national registry records, did not find higher rates of hospitalization among cement workers (4.9%) than among blue-collar workers (3.9%). However, white-collar workers had significantly lower rates of hospitalization (2.9%). In addition, there was an increasing tendency towards hospitalization with COPD with increasing duration of cement dust exposure up to 30 years (13). Dust exposure is probably lower in Scandinavia than in Tanzania. Cigarette smoking has been reported to be the major cause of COPD worldwide, but much remains to be learned about other causes (14). A well-designed community-based study in the United States reported a significantly increased prevalence of COPD among dust-exposed workers (15). Exposure to dust has been associated with COPD in workplaces or occupations such as coal and gold mines (16), tunnel construction (17), concrete manufacturing (18), food processing, bakeries, chemical processing and spray painting (19), and cotton processing, farming, welding, painting, foundry and refractory brick manufacturing (20).

This study investigated the relationship between cumulative total dust exposure and the risk of chronic respiratory symptoms and COPD among exposed and control workers at a Tanzanian Portland cement factory with implications for identifying strategies for prevention.

Study population and methods

Study population and study design

This cross-sectional study took place between June and August 2002 among workers at the Tanzania Portland cement factory in Dar Es Salaam, Tanzania. The sample size was derived on the basis of an estimated prevalence of chronic respiratory symptoms of 15% among "healthy" east African workers unexposed to dust (21). According to a double-sided *t*-test ($P=0.05$) using a rate ratio of 2 for the exposed group, a sample size of 120 exposed workers and 120 controls was required to achieve a power of 80%. The exposed group included all the workers in the production department ($N=126$), comprised of a crusher ($N=20$), a crane ($N=15$), a raw mill ($N=17$), a kiln ($N=30$), a cement mill ($N=12$), and a packing operation ($N=32$). The control group included only maintenance workers ($N=88$) and randomly selected administration office workers ($N=32$). The ethics committees of west Norway and Tanzania approved the study, and permission to conduct the study was granted by the factory management. All of the participants gave their informed consent after the purpose and methods of the study were clearly explained.

Sampling of the total cement dust level

A total of 120 full-shift personal "total" cement dust measurements were carried out for 80 randomly selected workers from the 8 occupational groups using closed-faced 37-mm Millipore samplers connected to a sampling pump. Overall, the concentrations of nine total dust samples were considered to be outliers and were removed during the analysis. The identification of outliers was done by the SPSS version 11.5 statistical package (SPSS Inc, Chicago, IL, USA), and they were identified as values laying more than $(1.5 \times \text{IQR}) + Q_3$, where IQR is the interquartile range and Q_3 is third quartile. In the overall data set, outliers were from the crusher (63 mg/m³), the crane (47.7, 52.6, 82.2, 93.1, 120.4, and 139.8 mg/m³), and the packing operation (152.3 and 229.2 mg/m³). The arithmetic mean of the total dust concentrations within each occupational group was used in the calculation of the cumulative total dust exposure. The cumulative total dust exposure for each worker was calculated as the sum of the products of the arithmetic mean of the dust concentration and the years worked in the specific work area, expressed as mg/m³-years. Details concerning the total dust exposure assessment have been presented recently elsewhere (22).

Questionnaire

The questionnaire used was a modified version of the British Medical Research Council respiratory questionnaire (23) translated into Kiswahili, the national language in Tanzania. It consisted of questions on demographics, work history, use of personal respiratory protective equipment, smoking habits, and respiratory symptoms. The participants received the questionnaire before they started the morning shift and were asked to complete and deliver it to the investigator after the shift or on the following day. The principal investigator checked the questionnaire to ensure that the worker completed it. For the respiratory symptoms, the participants were classified as having chronic cough if they answered yes to all of the following four questions: Do you usually cough first thing in the morning?, Do you usually cough during the day or night?, Do you cough as much as 4–6 times a day or more in a week?, Do you cough like this on most days for as much as three consecutive months or more during the year? For chronic sputum production, the participants had to answer "yes" to all of four the following questions: Do you usually cough with sputum first thing in the morning?, Do you usually cough with sputum during the day or night?, Do you cough with sputum as much as 4–6 times a day or more in a week? Do you cough with sputum like this on most days for as long as 3 consecutive months or more during the year? The participants were classified

as having dyspnea if they answered "yes" to "Do you get shortness of breath when walking at your own pace on level ground?" They were classified as having a wheeze if they had ever experienced a whistling sound from the chest. Participants were considered as having work-related shortness of breath if they had ever experienced difficulties in breathing at work or immediately after work and the symptom improved while out of work or during days off. The participants were classified as having chronic bronchitis if they had chronic cough or sputum production almost daily for at least 3 months a year for at least 2 consecutive years.

In addition, the workers were asked if they had ever had asthma, a chest injury or operation, abnormalities of the vertebral column or thoracic cage, or any other severe debilitating diseases such as heart conditions, diabetes mellitus, anemia, or neuromuscular diseases. Never smokers were defined as lifelong nonsmokers, ex-smokers had quit at least 1 year before the survey, and current smokers smoked at the time of the survey, including those who had quit less than 1 year before. Ever-smokers comprised current smokers and ex-smokers. The pack-years smoked (smoking 20 cigarettes a day for 1 year) were calculated for the ex-smokers and current smokers.

Ventilatory function testing

Details concerning the ventilatory function testing and the results including forced vital capacity (FVC), forced expiratory volume in 1 second (FEV₁), FEV₁/FVC, and FEV₁/FVC <0.70 have been described elsewhere (24). Briefly, FVC and FEV₁ were measured using a Vitalograph (Ennis, Ireland) spirometer. The measurements and procedures, including calibration, data selection, and BTPS (body temperature and pressure saturated) correction, were in accordance with recommendations of the American Thoracic Society (ATS) (25). Measured values of FVC and FEV₁ were compared with predicted normal values based on the regression equation for male Tanzanians derived by Mustafa (26), given as:

$$\text{FVC (liters)} = 0.0604H - 0.016A - 6.14 \text{ and } \text{FEV}_1 \text{ (l/s)} = 0.046H - 0.022A - 3.864,$$

where, H is height in centimeters and A is age in years.

Diagnosis of chronic obstructive pulmonary disease

The currently used definition of COPD is based on the following statement by ATS: "a disease characterized by the presence of airflow obstruction due to chronic bronchitis or emphysema" (27). Thus, in our study, the diagnosis of COPD was made for workers with chronic bronchitis who also had spirometric airflow obstruction (19, 27, 28), defined as FEV₁ below the fifth percentile

for predicted values (29, 30). The FEV₁ results have been published previously (24), but they were used in our study for workers with chronic bronchitis for the objective diagnosis of COPD (19, 28, 31). In our study spirometry did not include reversibility testing.

Statistical analysis

The data were analyzed by SPSS version 11.5 for Windows (Chicago, IL, USA). The chi-square or Fisher's exact test was used to detect differences in the frequencies of categorical characteristics between the groups. Student's *t*-test or an analysis of variance was used to detect differences in the mean values between the groups. The differences in chronic respiratory symptoms between the exposed and control groups were analyzed using a logistic regression after adjustment for age, pack-years, duration of employment, and education (primary education = 0, postprimary education = 1). The cut-off points of the 25th and 75th percentile of the overall cumulative total dust exposure were used to create three cumulative dust exposure categories. Each chronic respiratory symptom was correlated with the three cumulative dust exposure categories with the use of a logistic regression to obtain an adjusted odds ratio (OR) and the 95% confidence interval (95% CI). The relationship between COPD and the cumulative dust exposure categories was analyzed analogously. A *P*-value of less than 0.05 was considered statistically significant.

Results

Study population

Ten (5 exposed and 5 controls) of the 246 workers invited to participate in the study did not attend. Thus the overall participation rate was 94.7%. Twenty-four (10.2%) of the workers had changed jobs in the course of their employment in the factory. Female workers (1 exposed and 8 controls) were excluded from the data analysis due to their small number. The remaining 120 exposed workers and 107 control workers were included in the analysis. For the ventilatory function assessment, three exposed workers and two controls were excluded due to unacceptable spirometry. Five workers (2 exposed and 3 controls) reported physician-diagnosed asthma. Four workers (2 exposed and 2 controls) reported past history of pulmonary tuberculosis. None of the examined workers reported having heart disease, chest injury or operation, or any other severe debilitating diseases. The exposed group and the controls differed in age (*P*<0.001), duration of employment (*P*=0.001), and education (*P*=0.017)

(table 1). The groups did not differ significantly in height, weight, smoking habits, or pack-years smoked (table 1). Altogether 45 of the 120 production workers (37.5%) and 20 of the 85 maintenance workers (23.5%) reported using a disposable facemask regularly. The type and quality of the facemasks could not be determined, but they resembled a disposable half-facemask type P1.

Total cement dust exposure

The exposed workers had a higher current and cumulative total dust exposure than the controls (table 1). The concentration of the current total dust exposure was higher for the workers in the crane [N=6, mean 20.2 (SD 10.4) mg/m³], packing [N=15, mean 18.7 (SD 9.3) mg/m³], and crushing [N=25, mean 17.2 (SD 8.3) mg/m³] than in work in the cement mill [N=8, mean 4.2 (SD 3.6) mg/m³], the kiln work [N=8, mean 4.1 (SD 3.5) mg/m³], the work in the raw mill [N=8, mean 2.2 (SD 1.2) mg/m³], maintenance [N=24, mean 2.1 (SD 2.6) mg/m³], and administration [N=17, mean 0.6 (SD 0.7) mg/m³].

The three cumulative dust exposure categories were 0.01–19.9 mg/m³-years (N=71), 20.0–99.9 mg/m³-years (N=110), and ≥100.0 mg/m³-years (N=46). The arithmetic mean concentration and standard deviation of the cumulative dust exposure in the three categories were 8.9 (SD 4.7) mg/m³-years, 41.7 (SD 15.4) mg/m³-years, and 306.2 (SD 131.9) mg/m³-years, respectively.

Chronic respiratory symptoms

The exposed group had a significantly higher prevalence than the controls for chronic cough (OR 4.5), chronic sputum production (OR 10.8), dyspnea (OR 5.3), work-related shortness of breath (OR 4.8), and chronic bronchitis (OR 5.5) (table 2). The production and maintenance workers who reported using a facemask (65 of 206 workers) had a significantly higher prevalence of chronic sputum production than those not using a facemask (33.8% versus 19.1%, OR 2.3, 95% CI 1.2–4.8) after adjustment for age, employment duration, pack-years, and education level. No significant difference was detected for the prevalence of other respiratory symptoms between the users and nonusers of facemasks.

The ever-smokers had a higher prevalence than the never-smokers for dyspnea (22.1% versus 9.4%, OR 2.5, 95% CI 1.2, 5.9) and chronic bronchitis (25.0% versus 9.4%, OR 3.1, 95% CI 1.4–6.9) after adjustment for age, duration of employment, and education. The differences between the ever-smokers and never-smokers were not significant for the other respiratory symptoms.

Cumulative dust exposure and respiratory symptoms

Chronic cough, chronic sputum production, dyspnea, work-related shortness of breath, and chronic bronchitis were significantly associated with a cumulative dust exposure of 20.0–99.9 and ≥100.0 versus

Table 1. Characteristics of the exposed and control workers at a Portland cement factory in Tanzania.

Group	Age (years)		Height (cm)		Weight (kg)		Tenure (years)		Education				Smoking status						Pack- years		Current dust (mg/m³)		Cumulative dust (mg/m³-years)	
									Primary		Postprimary		Never		Current		Ex							
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	N	%	N	%	N	%	N	%	N	%	Mean	SD	Mean	SD	Mean	SD
Exposed (N=120)	35.7	8.7	169.5	6.5	74.2	12.2	11.0	8.2	65	54.2	55	45.8	80	66.7	16	13.3	24	20.0	1.9	4.6	13.1	10.1	137.9	157.0
Controls (N=107)	40.4	8.2	169.6	6.0	73.2	14.1	14.8	8.2	41	38.3	66	61.7	79	73.8	16	14.9	11	10.3	2.6	6.1	1.5	2.1	25.5	17.0
P-value	<0.001 ^b		0.904 ^b		0.579 ^b		0.001 ^b		0.017 ^c				0.239 ^c		0.726 ^c		0.050 ^c		0.309 ^b		<0.001 ^b		<0.001 ^b	

^a 70 samples for the exposed and 41 for the controls.

^b Independent student's t-test.

^c Chi-square test.

Table 2. Prevalence of chronic respiratory symptoms in the exposed and control groups at a Tanzanian Portland cement factory—odds ratio and 95% confidence intervals (95% CI) analyzed by a logistic regression model adjusted for age, duration of employment, pack-years, and education level.

Symptom	Exposed group (N=120)		Control group (N=107)		OR ^a	95 % CI	P-value
	N	%	N	%			
Chronic cough	31	25.8	13	12.1	4.5	1.9–10.4	<0.001
Chronic sputum production	41	34.2	11	10.3	10.8	4.4–26.4	<0.001
Dyspnea	23	19.2	7	6.5	5.3	1.9–15.2	0.002
Work-related shortness of breath	20	16.7	5	4.7	4.8	1.6–14.2	0.005
Wheeze	15	12.5	4	3.7	2.9	0.9–9.9	0.075
Chronic bronchitis	24	20.0	8	7.5	5.5	2.0–15.3	0.001

^a Analyzed with the use of a logistic regression model adjusted for age, duration of employment, pack-years of smoking, and education.

Table 3. Odds ratio of the relationship between chronic respiratory symptoms and cumulative dust exposure at a Tanzanian Portland cement factory (N=227). (95% CI = 95% confidence interval, Ref = reference value)

Symptom	Prevalence		OR ^a	95% CI	P-value
	N	%			
Chronic cough					
0.01–19.9 mg/m ³ -year	2	2.8	Ref	.	.
20.0–99.9 mg/m ³ -year	21	19.1	3.1	1.4–6.9	<0.001
≥100.0 mg/m ³ -year	21	45.6	18.4	3.9–87.1	<0.001
Chronic sputum production					
0.01–19.9 mg/m ³ -year	6	8.4	Ref	.	.
20.0–99.9 mg/m ³ -year	19	17.3	7.5	3.3–17.0	<0.001
≥100.0 mg/m ³ -year	27	58.7	12.0	4.1–35.5	<0.001
Dyspnea					
0.01–19.9 mg/m ³ -year	4	5.6	Ref	.	.
20.0–99.9 mg/m ³ -year	11	10.0	4.1	1.6–10.6	0.004
≥100.0 mg/m ³ -year	15	32.6	7.2	1.9–26.1	0.003
Work-related shortness of breath					
0.01 – 19.9 mg/m ³ -year	3	4.2	Ref	.	.
20.0–99.9 mg/m ³ -year	9	8.2	3.5	1.3–9.4	0.01
≥100.0 mg/m ³ -year	13	28.3	7.5	1.8–31.4	0.006
Wheeze					
0.01–19.9 mg/m ³ -year	3	4.2	Ref	.	.
20.0–99.9 mg/m ³ -year	8	7.3	1.7	0.5–5.5	0.353
≥100.0 mg/m ³ -year	8	17.4	4.4	0.9–22.3	0.072
Chronic bronchitis					
0.01–19.9 mg/m ³ -year	3	4.2	Ref	.	.
20.0–99.9 mg/m ³ -year	13	11.8	3.7	1.5–9.2	0.004
≥100.0 mg/m ³ -year	16	34.8	9.6	2.4–38.4	0.001

^a Adjusted for age, pack-years, and education level.

<20.0 mg/m³-years (table 3). Wheezing was not significantly correlated with cumulative dust exposure (table 3).

Chronic obstructive pulmonary disease

Altogether 27 of the 32 workers with chronic bronchitis also had spirometric airflow obstruction. Thus the prevalence of COPD in the whole study population was 12.2% (27 of 222). More exposed workers had COPD (22 of 117, 18.8%) than controls (5 of 105, 4.8%) (Fisher's exact test, P=0.002).

The workers with COPD were significantly older (P=0.048) and had a longer employment duration (P=0.007), a higher prevalence of ever-smokers (P=0.025), and a higher cumulative dust exposure (P<0.001) than those without COPD (table 4). The adjusted odds ratio for COPD increased with increasing cumulative dust exposure and was significantly associated with the cumulative dust exposure ≥100.0 versus <20.00 mg/m³-years (OR 11.2) (table 5).

Discussion

Our findings confirm the previously reported higher prevalence of respiratory symptoms among exposed cement workers than among controls (1–4, 7, 8, 10). A recent study did not find any increased prevalence of respiratory symptoms among cement workers versus

Table 4. Characteristics of the workers with chronic obstructive pulmonary disease (COPD) at a Tanzanian Portland cement factory.

Group	Age (years)		Height (cm)		Weight (kg)		Tenure (years)		Education				Smoking status						Pack-years of smoking		Cumulative dust (mg/m ³ -years)	
									Primary		Postprimary		Ever		Current		Ex					
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	N	%	N	%	N	%	N	%	N	%	Mean	SD	Mean	SD
COPD (N=27)	41.0	7.9	169.7	6.8	72.4	11.6	17.8	9.5	16	59.3	11	40.7	13	48.1	7	25.9	6	22.2	4.5	8.1	243.3	217.2
No COPD (N=195)	37.6	8.8	169.5	6.2	73.9	13.4	12.3	8.1	89	45.6	106	54.4	53	27.2	24	12.3	29	14.9	1.9	4.9	66.6	96.7
P-value	0.048		0.860		0.527		0.007		0.184		0.025		0.056		0.326		0.114		<0.001 ^a			

^a Independent student's t-test.**Table 5.** Prevalence and odds ratio of the relationship between chronic obstructive pulmonary disease (COPD) and cumulative total dust exposure at a Tanzanian Portland cement factory (N=222). (OR = odds ratio, 95% CI = 95% confidence interval, Ref = reference value)

Cumulative dust exposure (mg/m ³ -years)	COPD (N=27)		OR ^a	95% CI	P-value	OR ^b	95% CI	P-value
	N	%						
0.01–19.9 (N=68)	2	7.4	Ref	.	.	Ref	.	.
20.0–99.9 (N=108)	10	37.0	4.8	1.9–12.2	0.035	4.6	0.9–12.6	0.098
>100.0 (N=46)	15	55.6	14.4	3.1–67.4	0.001	11.2	2.2–56.0	0.003

^a Logistic regression analysis, unadjusted (crude) estimates.^b Logistic regression analysis, adjusted for age, number of pack-years, and education level (primary versus postprimary).

blue-collar controls (11). However, that study examined former workers rather than current workers, and the estimated and measured dust levels were relatively low (11). Comparing symptom rates between studies is difficult because many factors vary, such as study populations, dust concentrations, duration of employment, age, smoking habits, and definition of the respiratory symptoms. The validity of our study was strengthened by the high response rate by both the exposed workers and the controls. Furthermore, several previous studies (1–4, 7) did not adjust for possible confounders of respiratory symptoms such as age and smoking, as done in our study.

Chronic cough, chronic sputum production, dyspnea, work-related shortness of breath, and chronic bronchitis were significantly correlated with cumulative total dust exposure. However, due to the methodological shortcomings of cross-sectional studies, we cannot prove a causal relationship. Our results are partly in agreement with previous studies from Mexico (6) and Morocco (12), which reported significant associations between estimated current dust exposure levels or categories and several respiratory symptoms. No association was found in Jordan, (8) Taiwan, (9) the United States (10), or Norway (11) between dust exposure (8–11) and most of the respiratory symptoms studied, but dust exposure in these studies were relatively low when compared with those of our study.

Twenty-seven workers were diagnosed as having COPD, and most of them were in the exposed group. Previous studies have reported that the risk factors for COPD include smoking, α_1 -antitrypsin deficiency, airway hyperresponsiveness, severe childhood respiratory infections, air pollution, and occupational exposures (14, 16, 20, 27, 28, 32). Except for occupational dust exposure and smoking, the contribution of the other risk factors was unknown in our study, but it was assumed to occur equally for both the exposed workers and the controls. Thus the difference in COPD between the exposed and controls was likely to be due to cement dust exposure. In a previous study in Norway, no difference was found in the prevalence of COPD between former cement workers and blue-collar workers, probably due to relatively low cement dust exposure (11). Reversibility testing of spirometry was not determined in our study. Thus it is possible that some COPD cases may have had reversible airflow obstruction. The standard diagnosis of COPD generally requires postbronchodilator spirometry (27, 28, 32).

COPD and high cumulative dust concentrations were significantly correlated after adjustment for age, education, and pack-years. Our results suggest that cement dust exposure may contribute to the development of COPD among heavily exposed workers irrespective of cigarette smoking or the number of pack-years. This

finding supports the hypothesis that the development of COPD is attributed to prolonged high dust exposure (14–20, 32, 33). Vestbo & Rasmussen (13), in Denmark, reported that cement dust exposure contributed less to COPD [relative risk (RR) 1.9] than heavy smoking (RR 7.8) did, but the combination of dust exposure and heavy smoking had a higher relative risk (RR 14.0). In their study the dust exposure was relatively low (median total dust 3.3 mg/m³), whereas pack-years for the COPD cases was relatively high (mean 10.3). In our study, 48.1% of the COPD cases were ever-smokers, but the number of pack-years was low and, therefore, probably not associated with COPD.

The odds ratio indicates that a worker who is exposed daily to 10 mg/m³ of total dust and works for more than 2 years will have a significant risk for developing most of the chronic respiratory symptoms. A significant risk for developing COPD is found for those working for more than 10 years at 10 mg/m³. The findings strongly indicate that the current occupational exposure limit for total cement dust (10 mg/m³) used in several countries, such as the United States (10), Norway (11), and the United Kingdom (34), is too high to protect the respiratory health of workers during their entire worklife in the factory. In our study, outliers for current total dust exposure were excluded in the analysis, but similar exposure-response findings with different odds ratio estimates were observed when the outliers were included.

Epidemiologic studies have several definitions of COPD, and comparing studies is therefore difficult (14). We have used the ATS definition in diagnosing COPD because it combines both chronic bronchitis and spirometric airway obstruction, a highly recommended criterion for COPD diagnosis (27, 28). However, The ATS definition may yield a lower COPD prevalence because the diagnosis is made when the disease is fairly advanced. The European Respiratory Society (ERS) and the Global Initiative for Chronic Obstructive Lung Disease (GOLD) definitions of COPD are based only on the presence of airway limitation (28, 32). Thus a higher prevalence of COPD may be obtained with these criteria (28). The use of chronic bronchitis in the ATS definition of COPD may generate confusion since it is widely used to diagnose mucus hypersecretion (35). Thus, in order to make the ATS definition of COPD operative, the inclusion of spirometric airway obstruction is recommended (28, 35). Spirometric airway obstruction, and thus the COPD prevalence, depends on reference values. In our study, the reference values were specific for male Tanzanians and were chosen according to ATS recommendations (28). In developing countries, especially in Africa, information on the prevalence of COPD is scarce (36), and comparing our rates with those of the general population is therefore impossible.

The ever-smokers were about three times more likely to report chronic bronchitis and dyspnea than the never-smokers. Therefore, the relative contribution of smoking in the development of respiratory symptoms should be of concern in the cement industry (5, 8, 12). The workers who reported using a facemask regularly were about twice as likely to report chronic sputum production as workers not using facemasks. A respiratory symptom may have prompted the workers to wear a facemask (37). Our results also suggest that the facemasks used may not prevent respiratory disorders (8). Secondary healthy-worker effects cannot be ruled out because workers with manifest respiratory disease cannot work under dusty conditions. Nevertheless, because unemployment is high in Tanzania, workers usually continue to work even if ill, and the healthy worker effect may therefore be smaller than in other countries.

In conclusion, cement workers seem to be at high risk for chronic respiratory symptoms and COPD from the cumulative cement dust exposure independent of smoking status. Preventive measures need to be taken, including controlling dust in the work environment and using high-quality personal protective masks. Health surveillance should be part of this preventive program. Since cigarette smoking is an additional risk factor affecting the respiratory airways, workers should be strongly discouraged from smoking.

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