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Original Article

Dust Exposure and Respiratory Symptoms among Cement Factory Workers in the United Arab Emirates

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Abstract: This study was conducted in a cement factory in the United Arab Emirates to assess cement dust exposure and its relationship to respiratory symptoms among workers. A total of 149 exposed and 78 unexposed workers participated in this cross-sectional study. Information on demographic and respiratory symptoms was collected by questionnaire. Personal total dust levels were determined by the gravimetric method. Concentration of the total dust ranged between 4.20 mg/m^3 in the crushers and 15.20 mg/m^3 in the packaging areas, and exceeded the exposure limit in the packaging and raw mill areas. The prevalence of respiratory symptoms was higher among the exposed workers, but the difference from that of unexposed workers was statistically significant only for cough (19.5%; OR=4.5; 95%CI=1.5–13.2), and phlegm (14.8%; OR=13.3; 95%CI=1.8–100.9). Cough and phlegm were found to be related to exposure to dust, cumulative dust and smoking habit, while chronic bronchitis was related to smoking habit. The few factory workers (19.5%) who used masks all the time had a lower prevalence rate of respiratory symptoms than those not using them. High dust level was the only variable that influenced the workers to use the mask all the time. It is recommended that control measures be adopted to reduce the dust and workers should be encouraged to use respiratory protection devices during their working time.

Key words: Cement dust, Respiratory symptoms, Cumulative total dust, Respiratory protection equipment, United Arab Emirates

Introduction

Cement is manufactured through a series of processes that include the mining, crushing and grinding of raw materials, blending and kiln burning to form clinker, cement milling and packaging. Dust is emitted during these processes exposing workers to dust.

Several researchers have reported that chronic occupational exposure to dust in cement factories leads to a greater prevalence of chronic respiratory symptoms and signs such as coughing, sputum, wheezing and dyspnea as well as altering the pulmonary function indices[1–5]. However, a few researchers have reported no significant difference between exposed and unexposed workers for most respiratory symptoms[6–8].

The main objectives of this study were to estimate the level of the dust in the factory and compare it with the exposure limit, determine the prevalence of respiratory symptoms among the exposed subjects and compare it with those among the unexposed subjects, and evaluate

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the workers' practice regarding the use of the respiratory protection equipment.

Subjects and Methods

This cross-sectional study was conducted at one of the cement factories in the United Arab Emirates. This factory was selected because no previous study had been carried out at it to assess dust exposure and respiratory health effects. A sample of 227 male workers was randomly selected from among those working at the factory. One hundred and forty-nine workers were exposed to dust and we refer to them as the exposed group. The other 78 subjects were not exposed to dust and were selected from the administration, finance and other departments; we refer to them as the unexposed group. The 149 exposed workers were employed in the crushers (n=18), raw mills (n=28), kilns (n=27), cement mills (n=33), and packaging (n=43) areas.

Dust assessment

Personal "total" dust measurements were carried out for randomly selected workers from production areas within the factory. Personal air samples were collected on pre-weighed cellulose acetate filter membranes (Millipore type AA; 0.8 µm pore size; 37 mm diameter) placed in a closed face 37 mm filter cassette connected to an SKC AFC 123 pump with a flow rate of 2.0 l/min. The sampling time varied from 380 to 420 min. The sampling pump was calibrated before and after sampling, and the average of the two readings was used to calculate the volume of the air sampled. The filter membrane was weighed before and after sampling using a microbalance with a detection limit of 0.01 mg. Finally, the concentration of the dust was calculated as follows:

Weight of the dust (mg) = Weight of the filter after sampling – weight of the filter before sampling.

Volume of air sampled in m^3 = flow rate of the pump in m^3 per minute multiplied by the time of the sampling in minutes.

Concentration of the dust in mg per m^3 = weight of the dust (mg) divided by the volume of air sampled in m^3.

The geometric mean of the total dust concentration was calculated for each area and used in the calculation of the cumulative total dust exposure. The cumulative dust exposure of each worker was calculated as the sum of the products of the geometric mean of the dust concentration and the years worked in the specific work area, and was expressed as mg per m^3 – years.

Respiratory symptoms

An interviewer–administered questionnaire, based on the British Medical Research Council Questionnaire on Respiratory Symptoms (BMRC)[9], was used in this study.

The questionnaire included questions about demographics, work history, use of personal respiratory protective equipment, smoking habits, and respiratory symptoms. According to BMRC, a worker was classified as having cough, phlegm, chronic bronchitis, dyspnea, shortness of breath and bronchial asthma following the flowcharts shown in Figs. 1, 2 and 3, respectively. In addition, workers were classified as having wheezing if they answered "yes" to the question: Does your chest ever produce a wheezing or whistling sound? Asthma was recorded if it had been diagnosed by a physician.

All interviews were conducted face to face, in English, by a trained research assistant and the investigators. Workers who were non-English speakers were interviewed in their native language. At the beginning of the interview the objectives of the study were explained to each participant and their informed verbal consent was obtained.

The subjects were informed that all information collected would be anonymous to secure confidentiality.

Walk-through survey

A walk-through survey was conducted to check the flow rate of the dust sampler pumps and to observe whether the workers in the factory were using respiratory protection equipment or not.

Statistical analysis

Data were analyzed using SPSS 14.0. Frequencies, percentages, means and standard deviations were calculated for appropriate variables. Student's *t*-test and analysis of variance (ANOVA) were used to evaluate differences between the means of two or more groups. When ANOVA produced a significant result, a pos hoc comparison using the Holm-Bonferroni method was used to explore differences between groups.

The χ^2 test was used to compare percentages. The cutoff point of the 50th percentile (median) of the overall cumulative total dust exposure was used to create two cumulative dust exposure groups. The prevalence rates of respiratory symptoms among each cumulative dust exposure group were compared with that of the unexposed group.

Logistic regression analysis was used to determine the most important factors (predictors) influencing each of the respiratory symptoms. The independent variables used

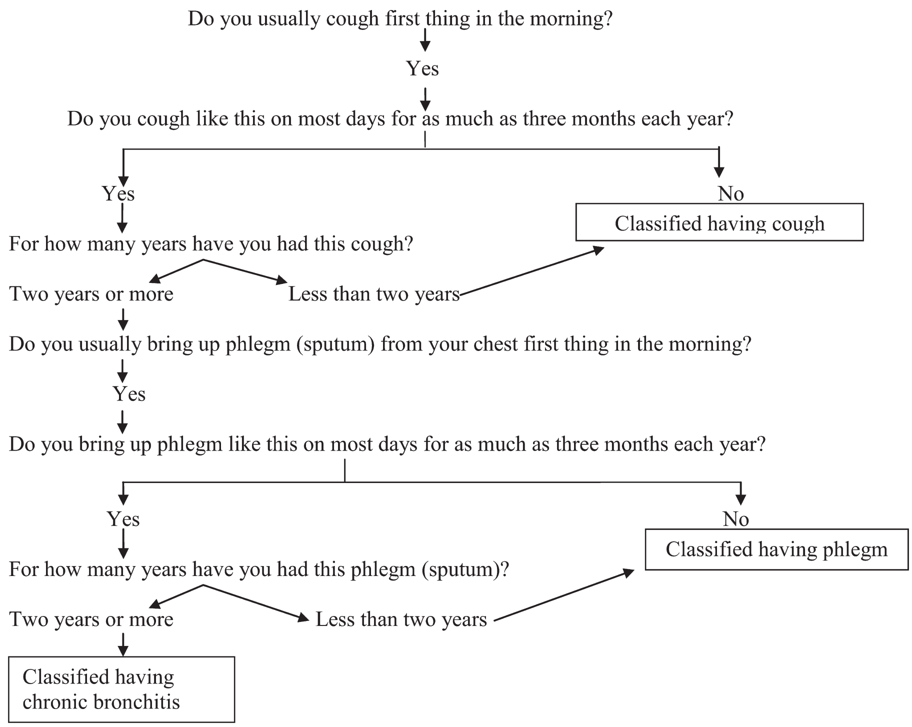

Fig. 1. Flowchart for Cough, Phlegm and Chronic Bronchitis.

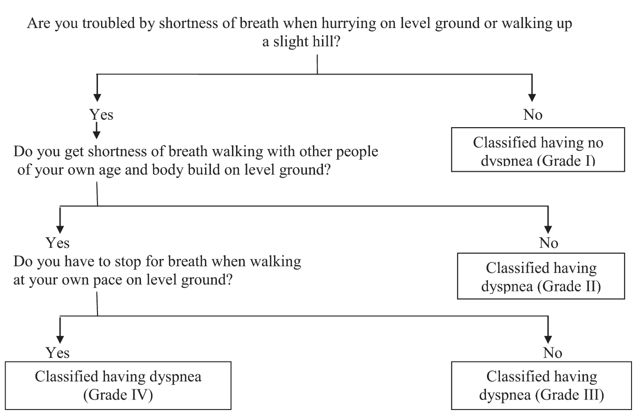

Fig. 2. Flowchart for Dyspnea Grades.

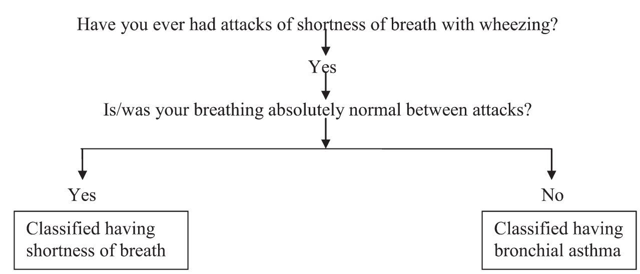

Fig. 3. Flowchart for Shortness of Breath and Bronchial Asthma.

were exposure to dust (yes=1, no=0), smoking habit (yes=1, no=0), years of work, and age. A p-value of less than 0.05 was considered statistically significant.

Ethics

The study was approved by the "Research and Ethical Committee of the College of the Health Sciences − University of Sharjah"

Results

Demographics characteristics

Table 1 shows the demographics characteristics of the study population. The exposed workers were significantly younger (38.2 yr) than the unexposed subjects (41.6 yr) (p=0.013). Out of the exposed workers about 30% and 52% had been employed in the plant for ten years or more and for more than five years, respectively. The majority of the exposed (89.9%) and unexposed subjects (93.4%) were Indians. Unexposed subjects were significantly more educated than the exposed group (p=0.002).

No significant difference was found between the exposed and unexposed groups with respect to the smoking habit, mean pack-years, and mean duration of service (p>0.05).

Table 1. Demographics and characteristics of the study population

Variable	Exposed (n= 149)	Unexposed (n=78)	p-value
	n (%)	n (%)	
Age (yr)			
< 25	8 (5.4)	1 (1.3)	
25–34	49 (32.9)	17 (21.8)	
35–44	54 (36.2)	33 (42.3)	0.100[a]
45–54	27 (18.1)	16 (20.5)	
≥ 55	11 (7.4)	11 (14.1)	
Mean (SD)	38.2 (9.7)	41.6 (9.5)	0.013[b]
Ethnic Group			
Indians	134 (89.9)	71 (93.4)	
Others	15 (10.1)	7 (6.6)	1.000[a]
Years of Education			
≤ 5	4 (2.7)	2 (2.6)	
6–10	64 (43.0)	24 (30.8)	0.001[a]
11–15	79 (53.0)	39 (50.0)	
>15	2 (1.3)	13 (16.7)	
Mean (SD)	11.0 (2.5)	12.2 (3.0)	0.002[b]
Years of service			
< 5	72 (48.3)	31 (39.7)	
5–9	33 (22.1)	14 (17.9)	0.281[a]
10–14	12 (8.1)	10 (12.8)	
≥15	32 (21.5)	23 (29.5)	
Mean (SD)	8.1 (8.0)	10.1 (9.0)	0.099[b]
Smoking habit			
Current smokers	28 (18.8)	10 (12.8)	
Ex-smokers	16 (10.7)	7 (9.0)	0.435[a]
Non-smokers	105 (70.5)	61 (78.2)	
Mean Pack-years ± SD	3.9 (10.3)	4.9 (19.8)	0.624[b]

[a] χ^2 test, [b]Independent sample t-test.

Table 2. Personal total dust concentrations, cumulative total dust and subjective assessment of the dust by area

Area (No. of workers)	Geometric mean of personal total dust concentration in mg/m^3	Arithmetic mean of cumulative dust in mg/m^3/yr	Subjective assessment of the dust		
			Little n (%)	Mild n (%)	High n (%)
Crushers (18)	4.2	23.5	5 (27.8)	4 (22.2)	9 (50)
Raw mills (28)	12.8	137.2	2 (7.1)	6 (21.4)	20 (71.4)
Kilns (27)	5.3	37.8	4 (14.8)	12 (44.4)	11 (40.7)
Cement mills (33)	7.0	45.3	5 (15.2)	7 (21.2)	21 (63.6)
Packaging (43)	15.2	145.1	7 (16.3)	20 (46.5)	16 (37.2)
Total (149)	8.9	87.4	23 (15.4)	49 (32.9)	77 (51.7)

Levels of dust

As presented in Table 2, the geometric mean concentration of the current personal total dust exposure ranged between 4.20 mg/m^3 in the crushers area and 15.20 mg/m^3 in the packaging area. The dust concentration was higher for the workers in the cement packaging and raw mill areas than in the other areas.

ANOVA analysis found a significant difference between areas for the mean of the cumulative dust (p<0.001), and the dust concentrations in the packaging and raw mill areas were higher than in the other areas. The Holm-Bonferroni method revealed no significant difference between the packaging and raw mill areas, and no difference between the crushers, kilns, and cement mills areas.

The two cumulative dust exposure groups were 0.7–39.9 mg/m^3/yr (n=76), and >39.9 mg/m^3/yr (n=73). The mean concentration and standard deviation of the mean of the cumulative dust exposure of the two groups were 17.5 ± 10.8 mg/m^3/yr and 160.1 ± 119.0 mg/m^3/yr, respectively.

About 52% (77 workers) of the exposed subjects reported that the area where they worked was very dusty, 49 (32.9%) workers said their work was mildly dusty, and 23 (15.4%) workers said their work was a little dusty. Thirty-six (46.8%), 32 (41.6%), and 9 (11.7%) out of the 77 workers who claimed that their job was dusty worked in packaging and raw mills (dust level>10 mg/m^3), cement mills and kilns (dust level 5–10 mg/m^3), and crushers (dust level<5 mg/m^3), respectively.

Respiratory symptoms

As shown in Table 3, the exposed group had significantly higher prevalence rates than the unexposed group of cough (19.5%; OR=4.5; 95%CI=1.5–13.2), and phlegm (14.8%; OR=13.3; 95%CI=1.8–100.9). About 11% of the exposed workers had grade II or more severe forms of dyspnea, compared with 4% of the unexposed group. However, this difference was not statistically significant. Five workers (3.4%) of the exposed group had grade IV dyspnea, as compared to 2 workers (2.6%) of the unexposed group. All the three workers who reported a diagnosis of asthma were exposed to dust.

The prevalence of shortness of breath and chronic bronchitis was high among the exposed group compared with unexposed group, but not high enough to be statistically significant.

When respiratory symptoms were broken down by smoking habit, it was found that the prevalence rates of cough and phlegm were significantly higher among non-smoking factory workers than among non-smokers in the unexposed group (p=0.011 and p=0.014, respectively). In addition, the prevalence rates of wheezing, shortness of breath, dyspnea of grade II or more, chronic bronchitis, and diagnosed asthma among the non-smoking factory workers were higher than among their counterparts in the unexposed group, but the differences between the two groups were not significant.

As shown in Table 4, the prevalence of cough, phlegm, shortness of breath, chronic bronchitis, and diagnosed asthma increased with cumulative dust exposure. In addition, the prevalence of these respiratory symptoms among each of the two cumulative dust exposure groups was higher than that among the unexposed group. However, the differences were only statistically significant for cough (OR=4.5; 95%CI=1.5–13.2), and phlegm (OR=13.3; 95%CI=1.8–100.9).

Logistic regression analysis revealed that exposure to dust and smoking habit were the predictors (variables) of the symptoms of cough, and phlegm, while the smoking habit was the only predictor of chronic bronchitis (Table 5).

Practice

Respiratory protection devices (N95 particulate respirator masks) were available for the factory workers. One hundred and eighteen (79.2%) workers claimed that they used masks, 19 (12.8%) subjects used an ordinary cloth mask, and 12 (8.1%) subjects never used any respiratory protection devices to protect themselves from the dust. Twenty-nine (24.6%) out of the 118 workers who claimed to use the masks used them all the time, and the remaining 89 (75.4%) workers used them sometimes. Twenty-five (86.2%) out of the 29 workers who reported using the masks all the time were found wearing them during the walk-through survey.

Out of the 29 workers who claimed to use the mask all the time, 20 workers (69%) said that their jobs were very dusty, and 9 (31%) of them said mildly or a little dusty. In addition, 18 (62.1%) workers of them worked in areas where dust was higher than the standard, the packaging and raw mills areas.

Interestingly, 21 (72%) and 18 (81.8%) exposed workers who respectively claimed to have cough and phlegm, said they never or rarely used masks.

Furthermore, logistic regression analysis revealed that a dusty job (high dust level) was the only variable that influenced the workers to use a mask all the time.

Discussion

Occupational exposure to cement dust is known to be an important factor in the causation of respiratory symptoms and diseases[1–5]. Exposure to dust is unavoidable in cement factories, but it could be reduced through effective engineering control measures and/or proper use of appropriate respiratory protection equipment.

In this study, the mean concentration of the current personal total dust exposure in the raw mills and packaging areas exceeded the exposure limit suggested by the American Conference of Governmental Industrial Hygienists (ACGIH)[10] for total dust (less than 1% quartz), 10 mg/m^3.

The finding of this study that cement factory workers

Table 3. Prevalence of respiratory symptoms in the exposed and unexposed workers

Symptom	Exposed (n=149)	Unexposed (n=78)	OR[a] (95%CI)[b]	*p*-value[c]
	n (%)	n (%)		
Cough	29 (19.5)	4 (5.1)	4.5 (1.5–13.2)	0.003
Phlegm	22 (14.8)	1 (1.3)	13.3 (1.8–100.9)	0.001
Wheezing	3 (2.0)	2 (2.6)	0.8 (0.1–4.8)	1.000
Shortness of breath	7 (4.7)	1 (1.3)	3.8 (0.5–31.4)	0.269
Dyspnea grade II or more	16 (10.7)	3 (3.8)	3.0 (0.8–10.7)	0.083
Chronic bronchitis	9 (6.0)	1 (1.3)	4.9 (0.6–39.8)	0.170
Bronchial asthma	1 (0.7)	1 (1.3)	0.5 (0.03–8.4)	1.000
Diagnosed asthma	3 (2.0)	0	–	0.553

[a]Odds Ratio, [b]95% confidence interval, [c]Fisher's exact-test.

Table 4. Prevalence rates and odds ratios of the relationships between respiratory symptoms and cumulative dust exposure

Symptom	n (%)	OR[a] (95%CI)[b]	*p*-value[c]
Cough			
Unexposed (n=78)	4 (5.1)	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	12 (15.8)	3.5 (1.1–11.3)	0.036
> 39.9 $mg/m^3/yr$ (n=73)	17 (23.3)	5.6 (1.8–17.6)	0.002
Phlegm			
Unexposed (n=78)	1 (1.3)	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	9 (11.8)	10.3 (1.3–83.8)	0.009
> 39.9 $mg/m^3/yr$ (n=73)	13 (17.8)	16.7 (2.1–131.1)	0.001
Wheezing			
Unexposed (n=78)	2 (2.6)	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	1 (1.3)	0.5 (0.05–5.7)	1.000
> 39.9 $mg/m^3/yr$ (n=73)	2 (2.7)	1.1 (0.1–7.8)	1.000
Shortness of breath			
Unexposed (n=78)	1 (1.3)	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	3 (3.9)	3.2 (0.3–31.1)	0.364
> 39.9 $mg/m^3/yr$ (n=73)	4 (5.5)	4.5 (0.5–40.9)	0.198
Dyspnea grade2 or more			
Unexposed (n=78)	3 (3.8)	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	9 (11.8)	3.4 (0.9–12.9)	0.077
> 39.9 $mg/m^3/yr$ (n=73)	7 (9.6)	2.7 (0.7–10.7)	0.199
Chronic bronchitis			
Unexposed (n=78)	1 (1.3)	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	3 (3.9)	3.2 (0.3–31.1)	0.364
> 39.9 $mg/m^3/yr$ (n=73)	6 (8.2)	6.9 (0.8–58.7)	0.057
Chronic asthma			
Unexposed (n=78)	1 (1.3)	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	1 (1.3)	1.0 (0.06–16.7)	1.000
> 39.9 $mg/m^3/yr$ (n=73)	0	–	–
Diagnosed Asthma			
Unexposed (n=78)	0	Reference	–
0.7–39.9 $mg/m^3/yr$ (n=76)	1 (1.3)	–	0.494
> 39.9 $mg/m^3/yr$ (n=73)	2 (2.7)	–	0.232

[a]Odds Ratio, [b]95% confidence interval, [c]Fisher's exact-test.

Table 5. Logistic regression models for the respiratory symptoms

Variable	Coefficient (β)	SE	OR[a] (95%CI)[b]	*p*-value
Cough				
Exposure to cement	1.5	0.6	4.6 (1.5–14.0)	0.008
Smoking habit	1.4	0.4	4.1 (1.9–9.0)	0.001
Service duration	0.02	0.02	1.0 (0.9–1.1)	0.349
Phlegm				
Exposure to cement	2.5	1.0	11.7 (1.5–90.1)	0.018
Smoking habit	1.4	0.5	3.9 (1.6–9.7)	0.003
Service duration	–0.03	0.03	1.0 (0.9–1.0)	0.426
Chronic bronchitis				
Exposure to cement	1.4	1.1	4.2 (0.5–35.0)	0.180
Smoking habit	1.4	0.7	4.0 (1.1–15.0)	0.037
Service duration	–0.02	0.04	0.9 (0.9–1.1)	0.733

[a]Odds Ratio, [b]95% confidence interval.

in the packaging and raw mill areas had a higher occupational exposure to total dust is consistent with previous studies[2, 4, 11]. In addition to the packaging and raw mill areas, other studies have reported high dust levels in crushers[1, 2, 4, 11], cement mills[2, 11], and kilns[11].

The concentration of the total dust reported in the current study was higher than that found in studies conducted in Western countries[7, 8]. This is probably due to newer technology and effective control measures adopted in the Western countries.

The dust level in the packaging area was comparable to that reported in a Saudi Arabian study[2], higher than that reported in a Malaysian study[12], but lower than those reported in two Tanzanian studies[1, 13], two Iranian studies[5, 11] and an Ethiopian study[4]. The level of the dust in the crushers was lower than that reported by other researchers[1, 2, 4, 11, 13]. For the kilns the dust level was lower than those reported in studies from Iran[11] and Saudi Arabia[2], but higher than those reported in studies from Tanzania[1, 13], and Malaysia[12]. The dust level in the cement mills was lower than those reported in some studies[2, 11] and higher than others[1, 12]. For the raw mills the level was higher than those reported in an Iranian study[11] and a Tanzanian study[1], but lower than that in the Saudi Arabian study[2]. The variation of the dust levels reported in these studies is probably due to the different technologies used and control measures adopted in the cement industry in these other countries.

In agreement with most of the previous studies, the current study reported higher prevalence rates of several respiratory symptoms among the exposed cement workers than among the unexposed workers. In this study, the difference was statistically significant only for cough and phlegm, as reported by others[1–3, 5, 12, 13], although Zeyede *et al.*[4] and Abrons *et al.*[7] reported no significant differences between exposed and unexposed workers.

The prevalence rates of shortness of breath, dyspnea, and chronic bronchitis were higher among the exposed than the unexposed workers, but without significant difference, as reported in other studies[1–5, 13].

In contrast to Ballal *et al.*[2], Zeleke *et al.*[4], Al-Neaimi *et al.*[3], Abrons *et al.*[7] and Neghab *et al.*[5], but in agreement with Mwaiselage *et al.*[1], no significant difference was found between exposed and unexposed workers in regard to wheezing in this study. Mwaiselage *et al.*[13] reported no wheezing among both exposed and unexposed workers and by explanation they reported that wheezing may occur much later after the development of disease, and after a substantial decrease in pulmonary function indices.

The results of the present investigation are in agreement with previous studies[1, 2, 11] that the prevalence of several respiratory symptoms increases with increasing cumulative dust exposure.

In this investigation, the ever-smokers were four times more likely to have cough and phlegm than the never-smokers. Furthermore, logistic regression analysis showed that both cough and phlegm were related to exposure to dust and smoking habit. This result supports the finding of previous studies[14, 15] that smoking is an important contributory factor in the development of respiratory symptoms and should be of concern in the cement industry.

In this study, both exposure to dust and smoking habit were found to be predictors of cough and phlegm, while smoking was the only the predictor of chronic bronchitis. However, Ballal *et al.* reported smoking and tenure as predictors of cough and phlegm, and exposure to dust as the only predictor of wheezing, shortness of breath and asthma[2]. Abrons *et al.* reported that the prevalence of chronic phlegm among cement workers increased with tenure, and prevalence of wheezing increased with both tenure and dust level[7].

It is worth comparing the findings of this study with that conducted by Al-Neaimi *et al*. in the late 1990s in another cement factory in the UAE[3]. In the present study, the prevalence of cough among the exposed group was 19.5% compared with 29.9% in Al-Neaimi's study, phlegm production was 14.8% compared with 25.4%, wheezing was 2.0% compared with 7.5%, dyspnea was 10.7% compared with 20.9%, bronchitis 6.0% compared with 13.4 and asthma was 2.0% compared with 6%.

The low prevalence of respiratory symptoms reported in this study, compared with that reported by Al-Neaimi's study, is probably due to the introduction of effective safety measures such as modified filter and enclosed belt transportation systems for reducing the exposure of employees in cement factories in the UAE to respiratory hazards.

Despite the availability of respiratory protective equipment for the workers in this factory, only 19.5% of them used protective equipment during working hours. Similar and higher percentages were reported by others. Ahmed and Newson-Smith reported that 28.8% of cement workers wore masks all the time[16]. Mwaiselage *et al.* reported that 31.7% of cement workers in the production and maintenance areas used a disposable facemask regularly[1], and in another study Mwaiselage *et al.* reported that 41.2% of highly exposed workers reported using a facemask, but not during the whole shift[13]. Yassin and his colleagues reported that 21.7% of farmers wore oral–nasal masks during application of pesticides[17].

In our study, cement workers who reported using masks all the time had lower prevalence rates of respiratory symptoms than those not using them during working hours. This finding justifies the use of appropriate respiratory protection devices during working hours to protect workers from developing respiratory symptoms. In contrast, Mwaiselage *et al.* reported that facemask-users had a significantly higher prevalence of chronic sputum than those not using them, but they also found no significant difference between the two groups for the other respiratory symptoms[1]. This finding might be due to inappropriate (poor quality and not very effective) facemasks available to the workers at the site of their study compared to the N95 particulate respirator masks available to the workers in this study.

In conclusion, the current study showed a high level of cement dust, with prevalence rates of respiratory symptoms higher among the exposed workers than the unexposed workers; however, only the prevalence rates of cough and phlegm were related to cement dust. Our findings support the hypothesis that smoking is an important contributory factor in the development of respiratory symptoms and should be of concern in the cement industry. The findings of this study support the use of appropriate respiratory protection devices by workers during working hours to protect themselves from developing respiratory symptoms. The investigators recommend that control measures be adopted to reduce the dust and workers should be educated about the health effects and control measures of dust, and be encouraged to use respiratory protection devices during working time.

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