Industrial Health 2018, **56**, 49–52

**Short Communication**

# Prevalence of lung function impairment among Greek cement production workers: a cross-sectional study

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*Received January 6, 2017 and accepted August 15, 2017*
*Published online in J-STAGE August 22, 2017*

**Abstract: Greece is a significant cement producing country. The aim of this study was to investigate the prevalence and risk factors of lung function impairment among Greek cement workers. One hundred thirty- seven cement production workers participated in this study. In addition, 110 employees not exposed to cement dust comprised the control group. The concentration of cement total dust at workplace varied from 1.1 to 11.6 mg/m$^3$. In only one of the measurements, the Threshold Limit Level of 10 mg/m$^3$ has been exceeded. Cement production workers presented a higher prevalence of FEV1<80% in comparison to controls (13.9% vs. 2.7%; Chi-Square Test; $p$=0.002). Multivariate analysis has shown that cement production workers have recorded an almost 5 fold risk of low lung function, as expressed by FEV1<80%, in comparison to the reference population OR=4.92; 95% C.I.=1.22–12.62). Current smoking was associated with an almost 4- fold increased risk of FEV1<80% (OR=3.91;95% C.I.=1.32–11.56). In conclusion, we found a high prevalence of impaired lung function among Greek cement production workers, despite the fact that total and inhalable dust levels were below the occupational exposure limits.**

**Key words:** Cement, Dust, Worker, Spirometry, Greece

The production of cement is related to a process that includes multiple stages: quarrying, crushing, raw milling, blending, and production of clinker, milling and packing. It is well known that cement dust contains respirable particles with aerodynamic diameter ranged from 0.05 to 5 $\mu$m[1]. There is conflicting evidence on the association between exposure to cement dust and lung function impairment1[1,2]. Greece is a significant cement producing country[3]. To the best of our knowledge, there is no published information on the impact of the exposure to cement dust on the respiratory system in Greece. Consequently, the aim of our study was to investigate the prevalence and risk factors of lung function impairment among Greek cement workers.

*Study population*

A convenient sample (n=150) of blue collar cement workers at a Greek cement production plant was invited to participate in the cross-sectional study. One hundred thirty-seven cement production workers participated in the study (response rate: 91%). A convenient sample of 110 employees not exposed to cement dust comprised the reference (control) group. The control group consisted of office (white collar) employees outside the cement industry plant. The members of this group performed various administrative and clerical tasks.

*Environmental monitoring*

The assessment of the environmental exposure to cement dust (total and respirable fraction) for the study group was performed by the use of the gravimetric method. In particular, the air was drowning through a cellulose filter of known weight that was adapted in a personal sampler device that

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was attached to a sampling pump of fixed flow (MSA Company, Pittsburgh, Pennsylvania, USA). Reweighing of the filter, after sampling, gives a measurement of the dust weight, and thus of dust concentration at the workplace. In addition, a cyclone was used to separate respirable and oversize dust. Total or inhalable dust refers to dust particles with an aerodynamic diameter of 100 $\mu$m. Respirable dust refers to particles with an aerodynamic diameter of 5 $\mu$m as well as smaller particles. In total, 14 measurements of total and 22 measurements of respirable dust were performed.

*Spirometry*

All participants underwent spirometry by using a portable spirometer (Vitalograph, Buckingham, England). Spirometries were performed according to the ERS guidelines[4)]. Three technically satisfactory maximal forced exhalations were recorded and the best forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the ratio FEV1/FVC were taken into account for statistical analysis. Predictive values of the above parameters were extracted based on the recommendations of the European Coal and Steel Community. The evaluation of extracted values regarding the parameters of spirometry was based on GOLD criteria[5)]. In addition, the portable spirometer was calibrated with a three-l syringe.

*Statistical analysis*

Continuous variables are presented as mean (SD) and categorical variables as absolute (n) and relative (%) frequencies. Associations between categorical variables were explored by the use of $\chi^2$ test (univariate analysis). Continuous variables were tested for normality by Kolmogorov-Smirnov test. Univariate analysis of normally distributed continuous variables was performed by student's *t*-test. Logistic regression analysis was used as the multivariate analysis in order to assess the impact on symptomatic status, and respiratory function of occupational exposure to cement dust, smoking use, and age. In these models of multivariate analysis respiratory symptoms and FEV1<80%, were the dependent variable, while age, smoking, and occupational exposure to cement dust, were the independent ones. Odds ratios (OR) and 95% confidence interval (95% CI) were calculated. The level of statistical significance was set at 0.05. All statistical tests were two sided. Statistical analyses were performed with Epi info software.

*Ethics*

The protocol of the study has been approved by the Steering Committee of the Post Graduate Program "Applied Public and Environmental Hygiene" at the University of Thessaly, Greece.

The concentration of cement total dust at workplace varied from 1.1 to 11.6 mg/m$^3$. In only one of the measurements the Threshold Limit Level established in Greece of 10 mg/m$^3$ has been exceeded. The concentration of the respirable fraction of cement dust was below the national Threshold Limit Value of 5 mg/m$^3$, and ranged between 0.1 to 3.4 mg/m$^3$ The vast majority of the participants (n=198; 80%) were males and 49 (20%) females. The mean age of our sample was 47 yr old (SD=19) and the mean of duration of employment was 19 yr (SD=9.4). Regarding occupational exposure status, 137 (55.5%) participants were cement production workers and 110 (45.5%) comprised the control group. The gender and age distribution was similar in both exposure and control group. The overall prevalence of current smoking among participants was estimated at 56% (54.7% among cement production workers and 58.6% among controls; $p$=ns). Cement workers reported a significantly higher prevalence of respiratory symptoms in comparison to office workers (20% vs. 4%, respectively, $p$ value<0.05). Table 1 depicts the mean values of FEV1, FVC and FEV1/FVC by age group, smoking, occupational exposure status and duration of employment. The prevalence of the patients with a ratio FEV1/FVC <70% was numerically higher in cement vs. office workers (4.4% vs. 1.1%, respectively); however this difference was not statistically significant ($p$=0.1). Cement workers additionally demonstrated higher FVC mean value than the control group. Cement production workers, participants with age <47 yr old, and current smokers have recorded in significantly lower mean values of FEV1. The univariate analysis of FEV1<80% (Table 2) has shown that cement production workers and current smokers had a higher risk to present an FEV1<80%. In particular, the homogeneous group of cement production workers presented a higher prevalence of FEV1<80% in comparison to the subsample of controls (13.9% vs. 2.7%; $\chi^2$ Test; $p$=0.002). The prevalence of FEV1<80% increased with duration of employment and also with age. Current smokers have had a higher prevalence of FEV1<80% in comparison to non-current smokers (12.2% vs. 4.6%, respectively; $\chi^2$ Test; $p$=0.038). Table 3 presents the results of the logistic regression analysis of FEVI<80%. Cement production workers have recorded an almost 5 fold risk of FEV1<80% in comparison to the reference population OR=4.92; 95% C.I.=1.22–12.62). Current smoking was associated with an almost 4- fold increased risk of FEV1<80% (OR=3.91;95% C.I.=1.32–11.56).

The present cross-sectional workplace-based study sug-

**Table 1. Distribution of selected spirometric mean values in relation to participants' socio-demographic features (n=247)**

| *Socio-demographic features* | SPIROMETRIC VALUES | | | | | |
|---|---|---|---|---|---|---|
| | FEV1/FVC (% predicted) | | FEV1 (% predicted) | | FVC (% predicted) | |
| | Mean | SD | Mean | SD | Mean | SD |
| Smoking | | | | | | |
| Current smokers | 96.4 | 6.7 | 97.1 | 16.2 | 100.8 | 16 |
| Non current smokers | 97.2 | 8.9 | 99.3 | 15.5 | 100.9 | 15.2 |
| Occupational status | | | | | | |
| Exposed to cement dust | 96.1 | 8.8 | 94.3 | 15.4 | 100.4 | 11.0 |
| Non exposed to cement dust | 97.6 | 6.0 | 95.8 | 15.8 | 99.4 | 15.0 |
| Age | | | | | | |
| ≤47 yr | 97.3 | 5.6 | 95.0 | 15.0 | 102 | 14.5 |
| >47 yr | 95.8 | 10.1 | 94.0 | 16.0 | 99.4 | 17.2 |
| Duration of employment | | | | | | |
| ≤ 19 yr | 97.2 | 5.5 | 99.2 | 12.8 | 101.4 | 13.4 |
| > 19 yr | 96.3 | 13.2 | 96.9 | 18.3 | 100.3 | 17.6 |

**Table 2. Univariate analysis of FEV1<80%**

| *Socio-demographic features* | PREVALENCE FEV1 (% predicted) | |
|---|---|---|
| | *<80* | *≥80* |
| Smoking | | |
| Current smokers | 12.2%* | 87.8% |
| Non-current smokers | 4.6% | 95.4% |
| Occupational status | | |
| Exposed to cement | 13.9%* | 86.1% |
| Non exposed to cement | 2.7% | 97.3% |
| Age | | |
| ≤47 yr | 5.4%* | 94.6% |
| >47 yr | 14.1% | 85.9% |
| Duration of employment | | |
| ≤ 19 yr | 5.0% | 95.0% |
| > 19 yr | 12.6% | 87.4% |

*$p<0.05$

**Table 3. Multivariate analysis of FEV1<80%**

| *Variable* | FEV1/80% | | *p* |
|---|---|---|---|
| | OR | 95% CI | |
| Smoking | | | |
| Current smokers | 3.91 | 1.32–11.56 | 0.014 |
| Non-current smokers | 1.00 (ref) | | |
| Occupational status | | | |
| Exposed to cement | 4.91 | 1.22–12.62 | 0.025 |
| Non exposed to cement | 1.00 (ref) | | |
| Age | | | |
| >47 yr | 3.19 | 0.79–12.88 | NS |
| ≤47 yr | 1.00 (ref) | | |
| Duration of employment | | | |
| >19 yr | 1.00 (ref) | | NS |
| ≤ 19 yr | 0.69 | 0.14–3.30 | NS |

NS: non significant

gests that cement production workers have recorded elevated prevalence of abnormal lung function in comparison to the control population. The evidence on the association between exposure to cement dust and lung function impairment is controversial. There are several studies suggested a positive association[6–12] whereas other found no association[13, 14]. However, it is of note that two recent well-conducted multi-national studies found a strong association between exposure to cement dust and lung function decline. In particular, Nordby *et al.*, in a multinational study supported by the European Cement Association (CEMBUREAU) reported reduced lung volumes among cement dust exposed workers[15]. In this context, a prospective study of workers employed in 24 cement production plants from 8 countries found that occupational exposure to cement dust was associated with reduced lung function parameters[16]. It is worth mentioning that we observed increased lung function impairment among cement production workers despite the fact that the measured levels of total and respirable dust were below the national occupational exposure limits. It has been suggested by other researchers that the current occupational exposure limit for total dust (10 mg/m$^3$) is too high and should be reduced to protect the respiratory health of cement production workers[6]. We also found a high prevalence (56%) of current smoking among blue collar cement production workers. This finding corroborates previous studies among heavy industry workers in Greece[17, 18]. Since smoking is a significant contributing factor of lung function impairment, anti-smoking activities targeting blue collar workers may be warranted. Our study presents several limitations which need consideration. A first limitation is the cross-sectional design of the survey. A second limitation is related to sampling method used in our study. Our sample was convenient, and the results are hardly applicable across the board of all cement workers in Greece. An additional potential limitation of our study could be related to "healthy worker effect". In particular, ill cement production workers might have left exposed jobs, while healthy employees may have remained in jobs that could be hazardous. This selection bias could have resulted in an underestimation of the effect of cement dust on lung function parameters. Another limitation refers to the absence of longitudinal (historical) exposure data on the levels of cement dust. Last, despite the use of logistic regression analysis, we can't exclude a residual confounding effect of occupational status (blue vs. white collar workers) on FEV1. In conclusion, we found a high prevalence of obstructive ventilation pattern among Greek cement production workers despite the fact that total and inhalable dust levels were below the occupational exposure limits. The significant association between occupational exposure to cement dust and obstructive lung function ventilation pattern was independent of the impact of smoking on lung function indices.

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