



## Exposure to occupational dust and changes in pulmonary function among cobblestone paving workers of Jimma, Ethiopia

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### ABSTRACT

The classic diseases of "dusty" occupations may be on decline, but they are not yet extinct. Studies have found associations between changes in ambient particulate air pollution and increased cardiorespiratory morbidity and mortality. A cross-sectional comparative study design was employed on 127 male nonsmoker cobblestone paving workers and 194 matched employed office workers as a reference in order to assess changes in pulmonary function related to dust exposure among cobblestone road paving workers of Jimma zone, Ethiopia. Data was collected using structured questionnaires and spirometric measurements after ethical clearance was obtained. Data was analyzed using unpaired t-tests to examine the differences between the groups. P-values equal or less than 0.05 were considered statistically significant; odds were calculated at a 95% confidence interval. Cobblestone road paving workers had significantly higher odds of respiratory symptoms, dry cough ( $p < 0.05$ ), cough ( $p < 0.01$ ) and sore throat ( $p < 0.001$ ) compared to the reference. The FEV1 for workers exposed to cobblestone road paving workers ranged between 3.12 - 4.73 L, with a mean of  $3.96 \pm 0.6$  L, significantly lower than the reference groups who had a range of 3.3 - 4.78 L and a mean of  $4.01 \pm 0.6$  L ( $p < 0.05$ ). The mean value of the ratio of FEV1/FVC was significantly decreased in the cobblestone road paving workers compared to the controls ( $87.2$  (SD 4.3) v  $89.5$  (SD 5.4),  $p = 0.01$ ). In conclusion, the study revealed clear evidence of the need for health education and for the promotion of activities directed towards mitigating respiratory hazards in order to foster a safe and healthy work environment.

**Keywords:** air pollution, dust exposure, particulate matter, pulmonary function.

## Exposição à poeira e alterações na função pulmonar entre trabalhadores de pavimentação com pedregulhos em Jimma, Etiópia

### RESUMO

As doenças clássicas associadas com trabalhos em ambientes empoeirados podem estar diminuindo, porém ainda não extintas. Estudos realizados associaram mudanças na poluição do ar em ambientes empoeirados com o aumento da morbidade e mortalidade cardiorrespiratória. Neste estudo comparativo transversal foram analisados 127 trabalhadores masculinos de pavimentação de estradas com pedregulhos, não fumantes e que foram

comparados com 194 trabalhadores de escritório utilizados como referência para avaliar as alterações da função pulmonar relacionadas à exposição ao pó na zona de Jimma, Etiópia. Os dados foram coletados por meio de questionário estruturado após a autorização do Comitê de Ética e realizada a mensuração espirométrica. Os dados foram analisados utilizando-se o teste t não pareado para analisar a diferença entre os grupos. Valores de p igual ou menor que 0,05 foram considerados estatisticamente significativos e as razões de possibilidades foram calculadas com intervalo de confiança de 95%. Trabalhadores de pavimentação de estrada tiveram uma razão de possibilidade significativamente maior de sintomas respiratórios, como tosse seca ( $p < 0,05$ ), tosse ( $p < 0,01$ ) e dor de garganta ( $p < 0,001$ ) em relação ao grupo de referência. O FEV1 para trabalhadores expostos ao trabalho de pavimentação de estrada variou entre 3,12 - 4,73 L com uma média de  $3,96 \pm 0,6$  L significativamente menor do que os grupos de referência que apresentaram um intervalo de 3,3 - 4,78 L e média de  $4,01 \pm 0,6$  L ( $p < 0,05$ ). O valor médio da relação de FEV1/FVC foi significativamente menor para trabalhadores de pavimentação de estrada em comparação com o grupo de controle (87,2 (dp 4,3) contra 89,5 (dp 5,4);  $p = 0,01$ ). Em conclusão, o estudo revelou evidências claras da necessidade de educação e promoção da saúde voltada para riscos respiratórios para promover um ambiente de trabalho seguro e saudável.

**Palavras-chave:** poluição do ar, exposição à poeira, partículas em suspensão, função pulmonar.

## 1. INTRODUCTION

The classic diseases of "dusty" occupations may be on the decline; but they are not yet extinct. According to the World Health Organization (WHO), almost one-third of the global disease burden can be attributed to environmental risk factors (Prüss-Üstün and Corvalán, 2006). WHO also has listed dust-producing operations that include sandblasting, rock drilling, stone cutting, sawing, chipping, grinding, polishing, breaking of sand molds, "shake-out", granule handling operations such as weighing and mixing and transferring dusty raw materials and products, which are typical of cobblestone paving work operations. Workers today still suffer from a variety of illnesses caused by dust they inhaled from the work environment, including acute and chronic respiratory functional impairment (WHO, 1999).

Cobblestone paving is a simple and replicable technology; its ability to create thousands of jobs is impressive. More than 20 towns in Ethiopia, including Addis Ababa, have now institutionalised cobblestone paving construction. A poor road network, expensive asphalt roads, declining economic activities, increased poverty and unemployment were some of the factors which influenced the city to find a road building technology that was labour-intensive, durable and easy to maintain (Ethiopia, 2011). However, like most road works, it presents respiratory occupational concerns which are worthy of study.

Many studies have found associations between daily changes in ambient particulate air pollution and increased cardiorespiratory hospital admissions, along with cardiorespiratory mortality (Nyberg and Pershagen, 2000). One approach to assessing the potential chronic effects of air pollution is to determine changes on lung functions by measuring volumes and determining lung capacities. Spirometry is the most common of all pulmonary function tests used to diagnose and monitor respiratory problems. Moreover, the measurement and monitoring of lung volume and capacity in order to rate occupational hazard is used to produce norms or policies related to preventive measure against occupational air pollutants (NIOSH, 2012).

According to a recent review of chronic obstructive pulmonary disease (COPD), 25% to 45% of patients diagnosed with the disease have never smoked, which makes occupational exposure as an attributing cause of COPD more likely (Salvi and Barnes, 2009). In developed countries, an estimated 15% of all COPD is attributable to occupational exposure (Hnizdo and

Vallyathan, 2003). A Malaysian study has shown association of total dust exposure and respiratory symptoms such as cough, phlegm, chest tightness and also with lung function indices (Noor et al., 2000). Similarly, in panel studies, acute episodes of particulate air pollution have been associated with increased incidence of respiratory symptoms, and decreased lung functions (Pope et al., 1995).

In order to minimize occupation-related pulmonary risk of air pollution, prevention and continuous monitoring systems are necessary to provide norms for adequate personal respiratory protective measures for chronically exposed people. Thus, this study aimed to show existing changes in pulmonary function related to dust exposure, if any, and to generate evidence to integrate primary prevention methods towards dust-related mortality and morbidity.

## 2. METHOD

The study was conducted in Jimma town, located in the Oromia province of Ethiopia, 354 km South West of the capital Addis Ababa. The town has a temperature that ranges from 20-30 °C and with average annual rainfall of 800-2500 mm<sup>3</sup>. The town has an altitude of 1750-2000 m above sea level. A cross-sectional comparative study design was employed on 127 male nonsmoker cobblestone paving workers and 194 nonsmoker government-employed office workers as a reference. Sample size was calculated using OpenEpi info software assuming two-sided confidence level (1-alpha) of 95, a Power of 80, a ratio of Controls to Cases of two, a hypothetical proportion of controls with an exposure of 40, a hypothetical proportion of cases with exposure of 57.14 with least extreme Odds Ratio to be detected of 2.00 of non-response rate of 15%. Data was collected using a structured questionnaire and spirometric measurement using lung function measurement was performed using a portable digital Spirometer (Vitalograph 2120), after ethical clearance was obtained from the review board of the College of Public Health and Medical Sciences, Jimma University, Ethiopia. Cobblestone paving workers were matched with the reference by confounding factors to increase the efficiency of statistical analysis. Age, sex, weight and height were used for matching. The reference subjects were randomly selected after the number of study subjects (cobblestone paving workers) was saturated. Subjects who take short-acting bronco dilators or had medically diagnosed pulmonary disease or who had been on an anti-Tuberculosis drug for the preceding six months, workers with any form of oral lesion or bleeding, subjects with an active upper respiratory infection and with chest deformities were excluded. Data was analyzed using unpaired t-tests to examine the difference between the groups. P-values equal or less than 0.05 were considered statistically significant. Odds were calculated at a 95% confidence interval).

## 3. RESULTS

### 3.1. Socio-demographic characters

Among 321 respondents, 194 were government-employed office workers and 127 were cobblestone paving workers. Respondents were comparable among the groups, with a mean (sd) age of 26.4±9 years for cobblestone and 27±5 for the reference (Table1). The reference groups were more educated (grouped) compared to cobblestone paving workers (2 ±1.2 vs. 3±1.4, where primary, secondary and territory levels educations are assumed hierarchically). Similarly, the reference groups had worked more years at their current jobs than compared to the cobblestone workers (3.3±1.4 vs. 7±3.9 years).

**Table 1.** Comparisons of the study subjects and the reference population in Jimma, Ethiopia, 2013.

| Variables                    | Cobblestone workers<br>N=127 | Reference group<br>N=194 | P value |
|------------------------------|------------------------------|--------------------------|---------|
| Age                          | 26.4±9 years                 | 27±5                     | 0.65    |
| Duration at current work     | 3.3±1.4 years                | 7±3.9                    | 0.02*   |
| Weight                       | 59±9.6 kg                    | 61±7.7                   | 0.32    |
| height                       | 162±8.3 kg                   | 163±4.2                  | 0.53    |
| Educational status (grouped) | 2 ±1.2                       | 3±1.4                    | 0.01*   |

\*significant.

The study result showed (Table 2) that Cobblestone paving workers had a higher frequency and odds of respiratory symptoms. Having dry cough ( $p < 0.05$ ), Cough with sputum production (OR=4.957,  $p < 0.01$ ) and sore throat (OR=5.842,  $p < 0.001$ ) showed a significant statistical association compared to the reference. They also had a higher prevalence of dyspnea 9 (7%), diagnosed lower respiratory infection 9 (7%) and wheezing 8 (6.2%), but were not statistically significant. Utilization of protective devices by cobblestone paving workers was 3.2%. The most common reasons for not using protective devices were “dust of such kind don’t harm” 65%, “I don’t have mask” 31%, and “unmasking is better” 17%.

**Table 2.** Occurrence and frequency of respiratory symptoms in last three months among cobblestone paving workers and references population in Jimma, Ethiopia, 2013.

| Respiratory symptoms | Cobblestone workers<br>n=127 | Reference group<br>n=194 | OR    | CI            | P value |
|----------------------|------------------------------|--------------------------|-------|---------------|---------|
| Dry cough            | 17 (13.4%)                   | 11 (5.6%)                | 2.571 | 1.093- 6.119  | 0.028*  |
| dyspnea              | 9 (7%)                       | 10 (5.2%)                | 1.403 | 0.506- 3.872  | 0.634   |
| Cough with sputum    | 12 (9.4%)                    | 4 (2%)                   | 4.957 | 1.439- 18.689 | 0.007*  |
| Sore throat          | 17 (13.4%)                   | 5 (2.5%)                 | 5.842 | 1.956- 18.660 | 0.001*  |
| Chest wheezing       | 8 (6.2%)                     | 6 (3.1%)                 | 1.890 | 0.578- 6.309  | 0.372   |
| Diagnosed LRTI**     | 9 (7%)                       | 7 (3.6%)                 | 1.907 | 0.629- 5.867  | 0.316   |

\* Significant; \*\*lower respiratory tract infection.

Spirometric measurement were recorded at ambient temperatures of 20-24°C and corrected to body temperature and pressure saturated with water vapor (BTPS). The mean (sd) of Forced Vital Capacity (FVC) of the cobblestone paving workers ranged between 3.7-5.1 L with a mean 4.4±0.5 L lower than the reference, who had a mean (sd) 4.5± 0.6 L, but not

statistically significant (Table 3). The forced expiratory volume in one second (FEV1) of cobblestone paving workers ranged between 3.12 -4.73 L with a mean of  $3.96 \pm 0.6$  L, significantly lower than FEV1 of the reference subjects' FEV1, ranged 3.3-4.78 L and a mean of  $4.01 \pm 0.6$ .

**Table 3.** Comparisons of pulmonary volumes among cobblestone paving workers and references population in Jimma, Ethiopia, 2013.

| <b>Pulmonary functions</b> | <b>Cobblestone workers</b><br>Mean (sd) | <b>Reference group</b><br>Mean (sd) | <b>P value</b> |
|----------------------------|---|-------------------------------------|----------------|
| FVC                        | 4.4 (0.5)                               | 4.5 (0.6)                           | 0.16           |
| FEV1                       | 3.96 (0.6)                              | 4.01 (0.6)                          | 0.03*          |
| FEV1%                      | 87.2 (4.3)                              | 89.5 (5.4)                          | 0.01*          |

\*Significant.

The mean value of the ratio of FEV1% significantly decreased in the cobblestone paving workers compared to the reference ( $87.2 \pm 4.3$  vs  $89. \pm 5.5$ ,  $p = 0.01$ ). There appeared to be no statistically significant differences in FVC between cobblestone paving workers and the reference, although cobblestone paving tended to have lower lung function parameters. On the contrary, FEV1 and FEV1% showed a significant reduction (Tables 3 and 4) among cobblestone paving workers ( $P < 0.05$ ). Tests for association conducted by independent t test with 95% CI revealed that there is a significant association between the duration of work in years and the FEV1. The result showed reduced FEV1 among cobblestone paving workers with longer durations of work ( $P < 0.001$ ).

**Table 4.** Duration of exposure (adjusted) and lung function among cobblestone paving workers: In dependent sample t-test, Jimma, Ethiopia. 2013.

| <b>Lung function</b> | <b>F-Statistics</b> | <b>T</b> | <b>P-value</b><br>(Two tailed test) | <b>95% Confidence Interval of</b><br><b>the Difference</b> |
|----------------------|---------------------|----------|-------------------------------------|--|
| FVC                  | 6.25                | 2.48     | 0.013*                              | (0.01-0.09)  |
| FEV1                 | 20.01               | 4.01     | 0.000*                              | (0.06-0.17)  |
| FEV1%                | 19.19               | 4.32     | 0.000*                              | (1.57-4.42)  |

\*Significant.

## 4. DISCUSSION

Classic epidemiological studies revealed chronic dust exposure among the major risk factors for chronic obstructive lung disease, while the recent clinical and pathological experimental studies have contributed further towards elucidating the pathophysiological mechanism by which dust can cause alteration that leads to the development of the disease (Hnizdo and Vallyathan, 2003). Cobblestone paving work involves stone crushing which continuously generates significant amount of dust in the atmosphere. The present study showed that the burden of air pollution is not evenly shared among the groups. Cobblestone paving workers were found to have more respiratory symptom and reduced lung volume. The socio-demographic comparisons of the study revealed that cobblestone paving workers were less educated than their matched (age, sex, height and weight) references. Many studies have

explored such differences in engagement with occupational hazardous work among less educated groups; such phenomenon was included in a workshop of the American Lung Association held in 2001 that focused on air pollution and health inequities (American Lung Association, 2001). The same finding was observed in a study done by O'Neill et al. (2012) and a review of Laurent et al. (2007).

More respiratory symptoms were found among exposed cobblestone paving workers than among the reference and were consistent with the Groneberg et al. (2006) review, which showed an aggregate of evidence focused on occupational causes of respiratory symptoms, particularly cough, being one of the most prevalent work-related airway symptoms. Similarly, Faria et al. (2006) and Schenker et al. (2005) also showed more respiratory symptoms among workers exposed to higher dust concentrations.

The spirometric data of the current study showed a lower but not a significant reduction in FVC measurements relative to the reference groups. However, FVC alone can't justify absence of alteration in pulmonary function as FVC can be normal or slightly decreased in patients with obstructive lung conditions (Gildea and McCarthy, 2003). Considering short duration of work for exposed groups, the lower FVC value is still clinically important as change in pulmonary parameters are the product of multiple years of exposure. There is a statistically significant reduction in FEV1 consistent with studies done by Jenny et al. (1960) and Yang et al. (1996) among workers exposed to cement and construction dust which was indicative of altered airway patency.

FEV1% is significantly reduced among cobblestone paving workers, which is similar to studies done by Al-Neaimi et al. (2001) and Mwaiselage et al. (2004). The results also showed a significant reduction in FEV1%, which indicates an obstructive impairment which could be due to mechanical irritation caused by exposed dust and individual susceptibility. Generally, the pulmonary function tests are more decreased in cobblestone workers as compared to the reference. Such pulmonary volume changes suggest an urgent need to improve dust control measures and health awareness towards dust prevention measures.

The data for use of protective devices was too small (3.2%), as was knowledge regarding protective devices among the cobblestone workers, which further justifies the need for health education on the prevention of occupational hazards and more specifically on respiratory ailments related to air pollution.

## 5. CONCLUSION

In conclusion, our study showed adequate evidence of the need for health education and other activity directed towards the reduction of respiratory hazards in order to foster a safe and healthy work environment, which will in turn maintain and promote workers' health, working capacity and productivity.

## 6. ACKNOWLEDGEMENTS

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