Pulmonary Tuberculosis among Stone Miners of India vis-à-vis Silica Exposure

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Abstract

Background: Tuberculosis is one of the biggest public health concerns in India with a prevalence of 195 cases per 100000. Silica is cytotoxic to macrophage which is primary defense mechanism to tubercular bacilli and, hence, exposure to silica dust increases risk for TB. Silica exposed persons are at 2.8 to 39 times greater risk of affected by pulmonary tuberculosis in comparison to healthy subjects.

Methodology: A cross-sectional epidemiological study was conducted among 935 workers in sandstone mining. Full-size posteroanterior view (PA) chest X-ray in full inspiration was evaluated and evidence of tuberculosis was noted. Fourier transform infrared spectrophotometer was used for determining the free silica in 23 dust samples. Results: 6.4% X-rays showed evidence of TB and silica dust concentration was 0.11 to 0.16 mg/m³. The TB cases significantly increased from 2% to 6% to 12.7% as the work exposure increased from <10 years to 11–20 years to >20 years respectively. 8.5% of the TB cases were seen among the workers having more than 10 years of work exposure. The odds ratio (95% CI) for work exposure more than 10 years to less than 10 years was 4.53 (1.92–10.65). Conclusion: Reduction of silica particles from work environment can significantly reduce the number of TB cases and hence wet drilling should be practiced and personal protective equipment should be regularly used.

Keywords: Mine workers, silica, stone mines, tuberculosis

Introduction

Tuberculosis (TB) is one of the biggest public health concerns in India with the prevalence of 195 cases per 100000 accounting for 27% of worlds TB cases. WHO reported that about 10 million people developed TB in 2017 with South East Asia region accounting for about 40% of the global TB burden.[1]

There are many risk factors for contacting TB like malnutrition, low socioeconomic status, HIV infection, exposure to silica dust, etc. Silica is cytotoxic to macrophage which is primary defense mechanism to tubercular bacilli and, hence, exposure to silica dust increases the risk for TB.[2] Silica exposed persons are at 2.8 to 39 times greater risk of affected by pulmonary TB in comparison to healthy subjects.[3-7] Susceptibility of silica exposed persons to TB has been demonstrated in multiple studies.[3,4,8]

Sandstone mining is an occupation where workers are exposed to high levels of silica. Sandstone mining is carried out in India since ancient times for building houses, carving idols, and decorative items. The mines are mostly in unorganized sector which are small in size with limited manpower and minimal mechanization. The workers belong to poor socioeconomic background with undernourishment making them vulnerable to tuberculosis. Hence, this study was taken up to determine the prevalence of TB among sandstone mine workers.

Material and Method

A cross-sectional epidemiological study was conducted among 935 workers from sandstone mines. The mines were...
located in 4 districts where stone mining activity is prevalent. Dholpur, Jodhpur, and Nagaur from Rajasthan state and Vidisha from Madhya Pradesh were selected for the study. The study was duly reviewed and approved by Institutional Ethics Committee (IEC) and signed informed consent was obtained from each study subject in their vernacular language. Each worker present and past occupational, personal history was recorded and medical examination along with full-size posteroanterior view (PA) chest X-ray in full inspiration was recorded. Evidence of tuberculosis was noted on the radiographs.

**Dust survey**

DGMS approved personal dust samplers (PDS) Make- SKC Inc. USA, Model- Sidekick-51Ex were used to collect 23 personal dust samples following a standard protocol from the stone mines of study area. The sampling was conducted for the complete shift and time weighted average for 8 h was calculated. Before study, each filter paper was weighed on a digital single pan balance and labeled. PDS was attached to the worker’s belt. Each personal sampling pump was calibrated using electronic calibrator. After sampling, the sampler was checked for flow rate and the actual flow rate was noted in the datasheet. The collected samples were carefully preserved and analyzed. Sidekick-51Ex has a correlation factor of 1.13 with MRE 113A concentration. Hence, the result obtained by this sampler was divided by 1.13 to get the equivalent MRE concentration in mg/m$^3$.[9]

Fourier transform infrared spectrophotometer (FTIR) Bruker make Alpha T model was used for determining the percentage of free silica in dust samples. NIOSH-7602 methodology was used to prepare pellets for analysis and the concentration of free silica was determined.[10]

**RESULTS**

The mean age of the study subject was 42.8 ± 10.0 years and the mean work exposure was 16.3 ± 8.6 years. Distribution of study subject according to age and work exposure is shown in Table 1.

In the study, it was observed that 60 cases (6.4%) had radiological evidence of TB. It was further observed that as the age and work exposure increase, there was a statistically significant increase in tuberculosis cases. Distribution of TB cases according to age and work exposure is shown in Table 2.

Manpower is limited in sandstone mines and each worker does all kind of jobs. Representative samples ($n = 23$) were collected to get information about silica exposure profile of workers from each study site. Distribution of tuberculosis cases in relation to mean free silica concentration is shown in Table 3.

Table 4 shows TB cases in relation to other factors like BMI, smoking, and alcohol consumption. It has been seen that most of the mine workers are smokers and alcoholic. Being subjective information, the reliability may be questionable. None of the workers had given history of HIV status.

### Table 1: Distribution of study subjects according to demographic characteristic

| Characteristics      | Number (%) |
|----------------------|------------|
| Age group (years)    |            |
| 18-30 ($n=62$)       | 62 (6.6)   |
| 31-40 ($n=367$)      | 11 (3.0)   |
| 41-50 ($n=306$)      | 23 (7.5)   |
| >50 ($n=200$)        | 26 (13.0)  |
| Mean                 | 299 (32.0) |

### Table 2: Distribution of TB according to age and work exposure

| Characteristics      | Tuberculosis (%) |
|----------------------|------------------|
| Age group (years)    | $x^2/P$          |
| 18-30 ($n=62$)       | 0                |
| 31-40 ($n=367$)      | 11 (3.0)         | $x^2=20.54$ |
| 41-50 ($n=306$)      | 23 (7.5)         | $P < 0.0001$|
| >50 ($n=200$)        | 26 (13.0)        |               |
| Work exposure (years)| $x^2=25.37$      | $P < 0.0001$  |

### Table 3: TB cases in relation to silica concentration in dust samples

| Study Area (no. of dust samples) | Free Silica Concentration (mg/m$^3$) | Tb cases |
|----------------------------------|--------------------------------------|----------|
| Dholpur ($n=4$)                  | 0.137±0.003                          | 13 (4.3) |
| Jodhpur ($n=07$)                 | 0.139±0.115                          | 11 (3.3) |
| Nagaur ($n=08$)                  | 0.161±0.095                          | 10 (6.4) |
| Vidisha ($n=04$)                 | 0.116±0.030                          | 26 (17.9) |

### DISCUSSION

There are large numbers of sandstone mining in India with thousands of workers engaged in extraction. Most of the mines are very small and not in the government records where the workers are mostly poor, illiterate, undernourished, and migratory and thus are vulnerable to TB.

The present study evaluated chest X-rays for evidence of TB among 935 sandstone miners in four districts in relation to their silica exposure. Various studies conducted among mine workers depicted the prevalence of TB ranging from 10.7% to about 32%.[11-14]

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Further, it was observed that mean silica exposure was 770 (88) (ACGIH). The Indian standard should also be lowered in line with international standards. Second, workers should be encouraged for using personal protective equipment like dust mask during working hours for which awareness plays an important role.

Based on the study, it can be concluded that silica dust exposure along with malnutrition may be contributing factors toward the high prevalence of TB. The study is based on the radiological presence of TB on chest X-ray and did not include the microbiological evaluation of sputum. Hence, the prevalence of tuberculosis may be overestimation/underestimation. A large scale study with microbial sputum evaluation will give a better picture of the problem in stone mines of India.

### Table 4: TB cases in relation to BMI, smoking habits, and alcohol consumption

| Health Workers | Workers with Tb | Total |
|----------------|----------------|-------|
| BMI | | |
| <18.5 | 212 (24.2) | 40 (66.6) | 252 (26.9) |
| 18.5-24.9 | 451 (51.5) | 19 (31.7) | 470 (50.3) |
| 25-29.9 | 169 (19.3) | 1 (1.7) | 170 (18.2) |
| ≥30 | 43 (4.9) | 0 | 43 (4.6) |
| Smoking Status | | |
| Smoker | 299 (34.2) | 24 (40) | 323 (34.6) |
| Nonsmoker | 576 (65.8) | 36 (60) | 612 (61.1) |
| Alcohol Consumption | | |
| Alcoholic | 105 (12) | 18 (30) | 123 (13.2) |
| Nonalcoholic | 770 (88) | 42 (70) | 812 (86.8) |

Figures in parenthesis indicate percentage

The feasibility and efficacy of dust controls in reducing TB prevalence and mortality among exposed workers have been clearly demonstrated in multiple studies. For reduction of dust exposure of workers, two strategies are important. First, the reduction of silica particles from work environment can significantly reduce number of TB cases and, hence, wet drilling is recommended in stone mines to keep the silica concentration within the prescribed limits. The present permissible limit for free silica as per Indian standard in mines is of 0.15 mg/m³. It was observed that mean silica exposure of the workers was ranging from 0.11 to 0.16 mg/m³, which is toward the higher side of Indian standard. In comparison to India, permissible exposure limit (PEL) for crystalline silica standard adopted by National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA) is 0.05 mg/m³, while 0.025 mg/m³ is adopted by American Conference of Governmental Industrial Hygienists (ACGIH). The Indian standard should also be lowered in line with international standards. Second, workers should be encouraged for using personal protective equipment like dust mask during working hours for which awareness plays an important role.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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