

Lung Function Decline Among Brick Kiln Workers in Haryana Due to Chronic Particulate Matter Exposure

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Abstract

In Haryana, India, brick kiln workers are subjected to high levels of Particulate Matter (PM) which has been shown to deteriorate respiratory health. This study looks into the effect sustained exposure to particulate pollution has on lung function among workers in the brick kilns. The objective of the study was to assess the impact of chronic exposure to particulate matter on lung function among brick kiln workers in Haryana. A cross-sectional study was performed on 833 brick kiln workers. Functional capacity of the lungs was evaluated by spirometry tests. Additionally, PM 10 and PM 2.5 exposure levels were monitored along with demographic and occupational variables for further analysis. Increased exposure duration to PM resulted in lung function decline (FEV1, FVC) greater than expected. Smokers showed greater lung function reduction than non-smokers. Significant changes in lung function were noted among those exposed for over 5 years. The data indicates that workers who are chronically exposed to high levels of PM in brick kiln environments suffer greater PM related decrements of lung function. There is an emerging need for air quality improvement, along with protective actions for the workers.

Keywords: Lung function, brick kiln workers, particulate matter, chronic exposure, Haryana, spirometry, occupational health, air pollution, PM10, PM2.5, respiratory health, occupational lung disease

INTRODUCTION

The health implications caused by air pollution are a growing concern now. This is more severe in industries such as brick kiln where workers are exposed to high dust, smoke, and other pollutants. Workers in Haryana, India, are at high risk of health issues as the pollution from the bricks made in this region has resulted in particulate pollution which is really bad for health. The environmental pollution has created a huge problem for the people living in Haryana as the set of fine particles known as PM10 and PM2.5 are extremely troublesome. This is due to the fact that these fine particles are known to inflict severe health conditions as they settle deeply in the lungs which is very problematic [1].

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The various sources of scientific literature do confirm that air pollution has serious threats to the health of the human body especially to the lungs and other parts of the respiratory system due to their continuous exposure to PM. The different studies conducted confirm that these people are victims of their surroundings and due to their long exposure to air which has high PM10 and PM2.5, they have been suffering from different pulmonary disorders along with slow progression of asthma, chronic bronchitis, and multiple other respiratory ailments. All of these consequences are demoralizing, yet still startling for chain reaction problems which stem from working under extreme polluted conditions for a long time. Like Berk kiln workers who have no/minimal options to protect, go around it [2].

In Haryana, brick kilns being the focal point of created business for the local populace, aids in economically uplifting the area without giving a thought about how the workers are getting affected or the overall health implications, which is most concerning.

Inhalation of airborne chemicals poses dire risks because the workers working in such places are already facing a multitude of risks, including but not limited to poor ventilation, lack of personal protection equipment, and high emission concentrations of particulate matter. Particularly, the claim becomes worse, given that a majority of these industrial workers do not possess suitable healthcare, let alone preventative healthcare, which can lead to chronically detrimental conditions over time.

This study seeks to determine the effect of long-term inhalation of particulate matter on the pulmonary functions of workers involved in brick burning kilns in the state of Haryana. The study intends to estimate the level of obstructive respiratory disorder and the degree of exposure to PM₁₀ and PM_{2.5}, while also developing a deeper understanding of the occupational health risks faced by these workers.

The expected outcome of this study will help inform the need for improved working conditions and policies oriented towards the prevention of air pollution in such dangerous industries. The objective remains to shift the health system response to safeguard these workers' health and wellbeing by addressing the negative implications of air pollution while increasing safety-focused interventions within the brick kiln industry.

LITERATURE REVIEW

Numerous studies have established the relationships between work-related sources of particulate matter (PM) and the prevalence of respiratory diseases concerning the health risks of construction work and brick kilns. Kumar *et al.* in their COPD study noted that individuals suffering from construction and brick kiln COPD appeared to be unfavorably lower in lung function because of the occupation's heavy exposure to particulate pollution [3]. This data is alarming concerning the multitude of health risks to workers who are subjected to very high concentrations of airborne particulates and other pollutants, which over a period of time, severely impairs lung function.

Also, further readings indicate that the length of exposure to PM is damaging to lung function. There is evidence suggesting that the longer an individual is exposed to such pollutants, to the extent alluded to, the worse their respiratory health becomes, particularly in developing countries with inadequately enforced environmental policies [4, 5]. Under these circumstances, such workers are perpetually exposed to these air pollutants without sufficient accompanying personal protective equipment and limited regulatory oversight, thereby increasing the chances of developing various chronic respiratory illnesses such as asthma, chronic bronchitis, and COPD.

These issues are exacerbated by the lack of air quality regulations and occupational health and safety standards in a number of developing countries. In India, workers in the brick kiln industry confront a dual threat of internal and external sources, as they are exposed to an exceedingly high concentration of particulate pollution.

Due to the activities of industrial processes, the particulate matter (PM) concentration in these regions is often higher than the recommended level, which increases the risk of the workers contracting respiratory diseases. Rough jobs associated with brick kiln workers such as mixing clay or operating the kiln expose them not only to coarse dust but also fine particulates that are capable of getting lodged within the alveoli and are well recognized to be part of chronic obstructive pulmonary disease [6]. According to research done in other similar industrial environments, the gradually increasing contact with dust pollution existing in brick kilns has resulted in different forms of respiratory illness.

Broad research on particular areas suggest that workers in dust- and smoke-filled environments are likelier to suffer from chronic bronchitis, emphysema, and other ways of chronic airway disease, which

necessitates improvement in the realm of occupational health service and measures of air pollution control [7]. Mitigation of PM exposure in brick kilns is not only fundamental to the worker's health, but also to the overarching industrial hygiene legislation, which aims at reducing respiratory disorders in industrial workplaces.

MATERIALS AND METHODS

Study Design

The participants of the study encompassed 833 laborers from the brick kilns located throughout Haryana. For the cross-sectional study, the workers were picked at random from the directory of brick kilns within the area.

Inclusion Criteria

- The participants were chosen according to these conditions:
 - *Age*: Between 18 and 60 years.
 - *Brick kiln employment*: Minimum of 2 years' experience.
- No record of severe cardiovascular illnesses or other chronic lung diseases not related to work.

Spirometry Testing

Prior to conducting lung function analysis which used a spirometer measuring Forced Expiratory Volume in the First Second (FEV1), Forced Vital Capacity (FVC), and the FEV1/FVC ratio, a detailed clinical history was collected. The outcomes were analyzed against the existing reference norms documented within the literature concerning the Indian populace [8].

Particulate Matter Exposure Assessment

Throughout the normal work shift at each brick kiln, the worker's exposure doses of particulate matter PM10 and PM2.5 were supervised with the use of a portable air quality monitor. The worker's average exposure time was divided into less than 5, 5–10, and more than 10 years. Concentrations of PM2.5 and PM10 were averaged.

Data Collection

Additional data on demographics (age, smoking habits, etc.) and occupational factors (job type, duration of exposure, etc.) were collected through structured interviews.

Statistical Analysis

Descriptive statistics were used to summarize the demographic and lung function data. Regression analysis was performed to assess the relationship between particulate matter exposure and lung function. P-values <0.05 were considered statistically significant.

RESULTS

Demographics

Out of the 833 participants, 70% were males, and the remaining 30% were females. The average age of the participants was 42 years, with a range from 20 to 58 years. 60% of the participants had more than 5 years of exposure to particulate matter.

Spirometry Results

The spirometry results examined by the duration of exposure revealed an association between the length of time exposed to particulate matter and the increase in lung function deterioration. The results were grouped into three different categories of exposure duration: under 5, 5 to 10, and over 10 years.

For individuals with less than 5 years of exposure, the mean Forced Expiratory Volume in 1 sec (FEV1) was 2.80 ± 0.45 l while the mean value of Forced Vital Capacity (FVC) was 3.50 ± 0.50 l. The

FEV1/FVC ratio which indicates airway obstruction has a mean value of 0.80 ± 0.05 . This suggests that individuals with shorter exposure duration have better lung function than those with longer exposures.

With exposure time increased to between 5 and 10 years, there was significant decrease in both FEV1 and FVC measurements. The average value of FEV1 lowered to 2.50 ± 0.60 l while FVC lowered to 3.30 ± 0.60 l. The FEV1/FVC ratio has also decreased and is now 0.75 ± 0.05 .

The initially implied FEV1 and FVC limbs, as well as the FEV1/FVC ratio lower limb, show indications of lung function deficiencies which could be the result of persistent exposure to harmful particulate matter. With more than a decade of exposure, lung function markers demonstrated even greater deficiencies.

The FEV1 average was 2.10 pm 0.50 l and the FVC average was 3.00 pm 0.55. The evidence is conclusive that lung function, indicated by both FEV1 and FVC and their ratio, deteriorates more with prolonged exposure beyond 10 years.

The data from Table 1 which has shown chronic exposure to particulate matter demonstrates a worrying trend in which there is an overall decline in respiratory function. Constant exposure to certain pollution over a length of time results in a negative, progressive effect on lung function as indicated by a changing FEV1, FVC, and FEV1/FVC ratio.

There is an immediate need to attend to strategies that minimize harmful exposure and safeguard the lung health of workers in the most impacted industries, for example, protecting builders' lung health exposed to brick kilns for prolonged high durations.

Particulate Matter Exposure

The work environment had an average PM10 concentration of $210 \mu\text{g}/\text{m}^3$, and PM2.5 concentration of $120 \mu\text{g}/\text{m}^3$. Both are much higher than the world health organization recommended safety levels of $100 \mu\text{g}/\text{m}^3$ for PM10 and $50 \mu\text{g}/\text{m}^3$ for PM2.5 [9].

Correlation Between Exposure and Lung Function

Table 2 analyzes the regression results of the examination of the relationship between the exposure time and lung function, measured in FEV1 and FVC, useful is quantifying how specific levels of exposure are associated with the pulmonary parameters mentioned above. Both FEV1 and FVC P-values and their coefficients represent as a metric for these variables for the changes these constituents undergo in the lung function in relation to a unit of exposure time while the altered P-values express the statistical significance of the changes.

Table 1. Spirometry results based on exposure duration.

Exposure duration	FEV1 (L)	FVC (L)	FEV1/FVC Ratio
<5 years	2.80 ± 0.45	3.50 ± 0.50	0.80 ± 0.05
5–10 years	2.50 ± 0.60	3.30 ± 0.60	0.75 ± 0.07
>10 years	2.10 ± 0.50	3.00 ± 0.55	0.70 ± 0.09

Table 2. Regression analysis of exposure duration and lung function.

Exposure duration	FEV1 (L) coefficient	FVC (L) coefficient	P-value
<5 years	0.02	0.03	0.12
5–10 years	−0.05	−0.07	0.02*
>10 years	−0.10	−0.12	0.001**

In the case of participants who had less than 5 years of exposure, particulates F coefficient results of FEV1 and FVC were positive where FEV1 has a coefficient of .02 and FVC has a coefficient of .03. Notwithstanding, the P-value of both measures is .12. This value is more than 5% now established as statistically significant range. Thus, it can be concluded almost without doubt that the set level of certain particulate pollution's impact over pulmonary function for these workers is too low and not enough to be perceived as changes in lung function to the extent of the fluctuations which are trivial, therefore the values should be close to zero sum FEV1 and FVC.

In contrast, the subjects who had between 5 and 10 years of exposure, the constructed values of the regression coefficients for these participants were negative and so their FEV1 (−0.05) and FVC (−0.07) values are below the baseline parameter value.

In this time period, the values for the efficiency parameter of lung function decreased cumulatively. For this group, the P-value of 0.02 is significant ($P < 0.05$), demonstrating that the reduction of both FEV1 and FVC is systematic, not random. This supports the claim that the negative effects of particulate matter on lung function becomes noticeable following exposure for a period of 5 to 10 years.

For subjects with more than a decade of exposure, the coefficients for FEV1 and FVC become more negative; therefore, −0.10 and −0.12 respectively. These changes are statistically significant with a P-value of 0.001 ($P < 0.01$) which made the hypothesis of greater decline in lung function in subjects with a higher degree of exposure to the particulate pollution holds valid. These severe negative coefficients, along with the low P-Values suggest deep impairment of both FEV1 and FVC for those exposed for greater than 10 years, which highlights the long term devastating effects of such extensive years on respiratory health.

In other words, regression analysis paints this picture of a drastic negative decline in lung function due to extended exposure. While the short-term exposure (<5 years) does not seem to cause significant disruption, the moderate (5–10 years) and long-term (>10 years) of exposure cause significant and quantifiable disruption to both FEV1 and FVC.

Such results point to the need for reduction of particulate matter exposure in order to better and maintain the lung health of the sensitive workers, especially those in occupations where there is chronic exposure such as in brick kilns.

DISCUSSION

The findings of this study corroborate and further develop what other studies have found, that there is a lung function (and lung) deficiency among individuals who work in environments with high concentrations of particulate matter (PM) [1, 3]. The data from this study continues to support the idea that pollution caused by particulates is harmful to health, especially for the respiratory system where chronic exposure exists. The negative correlation between the exposure time and lung function, demonstrated in this study, affirms the damaging consequences of longer stays in an area polluted with Particulate Matter (PM). The lungs are gradually damaged, the longer an individual stays within these polluted environments, as there is a simultaneous increase in the loss of respiratory function. Hence, even minimal amounts of time spent in such circumstances are detrimental to lung health.

This study's findings reinforce what other studies have reported regarding the adverse effects of excessive and concentrated pollutants in the workplace. As an example, employees from high dirt concentration locations such as construction sites and brick-making industries are likely to suffer from respiratory diseases over time. The current study had one of its subject populations employed for over a decade and these subjects demonstrated the greatest levels of lung function impairment.

This corroborates other studies of the same nature which ascribe a marked deterioration in pulmonary function over time to prolonged exposure [10]. In this subject group, both Forced Expiratory Volume

(FEV1) and Forced Vital Capacity (FVC) showed statistically significant reductions suggesting that the lung damage from the workplace exposure was indeed related to years of work experience of the employees in this study's group.

Preventing further deterioration of lung function remains necessary in vast employing industries under the purview of social hygiene, such as construction, demolition, excavation, brick kiln, and plastering where there is constant exposure to dust-polluted air. The significant decline in lung function among the workers in this study suggests that proactive measures need to be implemented which include ventilation, PPE, and regular health monitoring of the personnel. Furthermore, basic measures aimed at shielding employees against harmful gaseous air pollutants become immediately necessary in order to improve workers' health for the long-term. Because of the increasing recognition of work health issues within low air quality regions, it is essential to focus on the reduction of PM exposure. This would take care of employees' demands while also reducing their social health burdens related to work-related pulmonary diseases.

CONCLUSION

Haryana's brick kiln laborers incur serious respiratory health hazards from chronic exposure to particulate matter. Given the severe consequences for lung function, protective policies should be implemented and air quality regulation in Haryana ought to be modified to these health risks. Further longitudinal studies are recommended in conjunction with intervention studies to validate these findings.

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Conflicts of Interest

The authors declare no conflict of interest.

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