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# Effect of Environmental Degradation and Occupational Disadvantages on Public Health: A Cross Sectional Study in Alwar, Rajasthan

**Virendra Singh Choudhary[1,*] | Geeta Chaudhary[1] | Dheerendra Choudhary[2]**

[1]Smt. Vidyawati College of Nursing, Jhansi - 284121, Uttar Pradesh (India)
[2]All India Institute of Medical Sciences, Raipur - 492099, Chhattisgarh (India)

***Corresponding author:** singhviren81@gmail.com

**Abstract:** The Matsya Industrial Area (MIA) has seen rapid industrial devolution and the Alwar district in Rajasthan had restrictions on surface mining which has brought about considerable environmental changes and occupational health issues. The aim of the study is to assess the influence of macro-environmental changes and Individual level work stressors on the multi-systemic medical health profiles of local populations and industrial workers. Multi-stage stratified random selection approach was used to pick 500 adults from Alwar district. The Medical and environmental data were collected by structured dependable techniques. Adjusted Odds Ratios (aOR) from Binary Logistic Regression and Beta Coefficients (β) from Stepwise Multiple Linear Regression were used to determine the contributing factor of medical susceptibility. The patients disclosed high incidence rates of Chronic Respiratory Dysfunctions (26.4%), Musculoskeletal Disorders (38.2) and Dermatological Pathologies (19.6%). Mining/industrial laborers had significantly lower Forced Vital Capacity (FVC) in comparison to non-industrial cohorts ($t(498) = -8.14$, $p<0.001$) as determined by independent samples t-tests. Multiple linear regression revealed working hours per day ($\beta= 0.34$, $p<0.001$) and inhabited nearness less than 1 km from the active industrial group ($\beta=0.29$, $p<0.001$) as main interpreters of systemic health deprivation score ($R^2=0.441$, $F = 63.81$, $p<0.001$). Severe hazards were identified for persons who need access to standard personal protection equipment using logistic regression models (aOR= 4.12, 95% CI: 2.45-6.92). Human induced changes in the environment along with improper workplace safety measures leads to substantial measured multi-systemic health morbidity in Alwar.

**Keywords:** Occupational health, environmental changes, stratified random sampling, Forced Vital Capacity (FVC), personal protection equipment

## 1. Introduction

### 1.1 Background and Purpose

With the rapid global urbanization, the large expansion of metropolitan areas is expected to have major environmental issues. The 2011 census showed that the number of cities with populations of more than a million climbed from 35 to 53, confirming an increasing trend in urban growth worldwide (Ministry of Urban Development, 2011). This expansion undoubtedly worsens the economic development and also displays various environmental risk factors [1].

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In low- and middle-income economies like India, the shift from traditional agriculture-based economies to regionalized industrial centers has created complicated, layered epidemiological risk profiles. The above-described outlines denote a unique dual issue: general dilapidation of environmental conservation (exposure at the macro level) and work-related health issues (exposure at micro level).

Alwar District is positioned in the North-Eastern part of Rajasthan. It is an important constituent of the National Capital Region (NCR). In other words, it presents a classic case study on the above-mentioned risk pathways. Geographically and technologically, Alwar is famous for having important manufacturing sectors which include MIA and dense industrial sectors of Bhiwadi which comprise chemical manufacturing, stone mining and crushing units, mineral processing and metal manufacturing units.

Ambient air quality parameters of Alwar indicate the fact that levels of respirable particulate matter (PM2.5 and PM10) and gaseous pollutants such as SO2 and NOx are consistently higher than average. This ambient unique deterioration is linked to serious water quality problems. Surface bodies like Agyara and Jaisamand reservoirs and deep groundwater aquifers have been affected by uncontrolled discharge of industrial solid wastes and poorly treated liquid wastes.

Working in these divisions is made worse by the immediate risks of the working environment and ambient contact. Workers in Alwar's stone mines, open cast mines and industrial units work long shifts (>8-10 hours daily) under extreme physical stress, excessive ambient noise, ergonomic stressors and heavy clouds of crystalline silica dust.

The association between exposure to chemicals in the manufacturing and COPD has been described in diverse world populations. In Spain, a recent study with more than 7500 subjects from the general population over 40 years of age showed that self-reported exposure to vapors, gasses, dusts and fumes (VGDF) was associated with COPD (odds ratio (OR) 1.22 95% confidence interval (CI) 1.03–1.44) with a population attributable fraction of 8.2%. On the basis of these results, numerous parameters should be assessed to further the understanding of the effect of occupational exposure on the development of COPD **[2]**.

Despite these evident connections, public health monitoring in chaotic industrial sectors remains fragmented. Epidemiological evaluations tend to consider ambient environmental pollution or direct occupational exposures separately, and not commonly to evaluate the interaction of these exposures on human health. This study fills the gap by reporting a wide cross-sectional investigation of a sample of 500 individuals of Alwar District, testing the joint effects of macro-environmental changes and micro-occupational risks in influencing multi-systemic clinical outcomes.

### 1.2 Literature Review

The international literature has studied epidemiology and occupational health widely, and with an environmental link. Local dynamics, however, are very unpredictable, depending on the area implementation of environmental laws and labor norms. Despite the growing awareness of the health effects of outdoor air pollution, mortality rates have grown by 66% in the last two decades **[3]**. Certainly, current data from the 2019 Lancet Commission on Planetary Health suggest that nearly 4-million deaths were linked to PM2.5 and 370,000 to environmental ozone exposure. The high environmental air pollution is connected with increased prevalence of respiratory tract illnesses **[4]**.

In the case of the Indian subcontinent, and more specifically in the arid topography of Rajasthan, mining and extraction operations drive the industrial landscape. Nandi et al. reports that > 3 million workers in India are at high risk of occupational exposure to silica. Studies of local clusters like Jodhpur, Nagaur and Kota indicate the high rates of chronic respiratory disorders including as silicosis, TB and asthma among sandstone mine and quarry workers **[5]**.

Environmental investigations in Alwar have also pointed to significant structural impoverishment. The current tracking of the Matsya Industrial Area and neighboring water bodies has shown that the releases of solid and liquid wastes have made the local surface waters unfit for human consumption with chemical and biochemical oxygen needs well over the allowable limits.

Using specialist evaluation software to monitor air quality, annual particle concentrations in Alwar have been demonstrated to consistently exceed both the Indian National Ambient Air Quality Standards (NAAQS) and World Health Organization (WHO) safety margins simultaneously. This background pollution leads to a high baseline risk for the general population of the area, which is elevated for those working directly in high-exposure industrial jobs.

### 1.3 Research Vacuum

Whereas the current literature establishes that ambient air pollution is a cause of respiratory disorders and mining is a cause of silicosis, there is a significant research vacuum in the combined health implications of these same exposures. Most studies are in good agreement with "community environmental exposure" and "industrial occupational exposure" as independent matters. Therefore, few statistical models explore the interaction between ambient residential proximity to the industrial region and everyday working stressors (e.g., long shifts, lack of protective equipment) in affecting overall health. The gaps are reported in this study through a planned cross-sectional design of Alwar District.

#### 1.3.1 Conceptual Framework

The present study used a modified Socio-Environmental Epidemiological Model. It demonstrates the association of macrolevel environmental stressors and microlevel work conditions to produce physiological results as described below (Figure 1):

**[Macro-Environment Changes]**
Elevation of Ambient PM2.5 / PM10
(MIA Effluents) Groundwater contamination
Close to active industrial clusters (<1 km)

**[Cardio-Respiratory & Systemic Health Deterioration]**
Decreased lung function (FVC/FEV1)
Chronic Obstructive Pulmonary Diseases/ Silicose
Musculoskeletal and Dermatological Pathology

**Micro-stressors of occupation**
Daily shift lengths (>8 hours)
Inhalation of Direct Crystalline Silica
PNP PPE Non availability / Non compliance
**(Moderated by)**
**[Socio-Demographic Moderators]**
Age, Sex, Smoking History, Literacy Status

**Figure 1:** Model of Epidemiology

#### 1.3.2 Goals

- To enumerate the prevalence of multi-systemic morbidities (respiratory, musculoskeletal, dermatological and cardiovascular complaints) among the population resident in Alwar District.
- To compare physiological health markers among occupational groups and exposure areas, e.g., Forced Vital Capacity (FVC), blood pressure.
- To compute the adjusted odds ratios (aOR) of clinical health deprivations for occupational susceptibilities, specific environmental exposures, and protection equipment compliance.
- To build an analytical linear model to evaluate the total health deprivation scores considering the joint effect of daily working hours, duration of employment and proximity to industrial area.

#### 1.3.3 Hypotheses

**H01:** The mean Forced Vital Capacity (FVC) of persons exposed to high dust industrial or mining environments is not significantly different from the mean FVC of persons working in non-dust non-industrial works.

**H1:** The mean Forced Vital Capacity (FVC) of individuals working in high-dust environments is much lower than non-industrial due to repeated intake of dust.

**H02:** The scores of systemic health degradation are not predicted significantly by the daily working hours and the vicinity of residence to industrial districts.

**H2:** Proximity to industrial areas (<1 km) and longer working hours per day (>8 hours) are statistically significant positive predictors of systemic health deterioration scores.

## 2. Research Methods

### 2.1 Cross-Sectional Analytical Design

The study design was observational, cross-sectional analytical to analyze exposures and health outcomes at the same time in the target group.

### 2.2 Study Area

The study was conducted at Alwar District, Rajasthan with the focus on the people around Matsya Industrial region (MIA), Bhiwadi industrial region and the open cast mining and stone-crushing sites of the tehsils of the district.

### 2.3 Sample Size Estimation

Sample size was calculated using the conventional formula for single proportion:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

The final sample size was determined to be N = 500 participants, rounded and fixed to provide an explanation for a predictable non-response rate and to provide appropriate power for multi-variable subgroup regressions.

### 2.4 Method of Sampling

The present study used a multi-stage stratified random sampling method.

**Stage 1:** The Alwar district was divided into industrial/mining and non-industrial sectors.

**Stage 2:** Random selection of clusters (villages and urban wards) within 5 km radius of this mining /industrial area

**Stage 3:** Systematic random sampling was used and eligible persons were recruited until the sample size reached the desired number of 500.

### 2.5 Inclusion and Exclusion Criteria

**2.5.1 Inclusion Criteria:** Subjects included in the study are

- Adult inhabitants 18-65 years,
- Living in the Alwar district for at least 2 years continuously and willing to undergo clinical examinations.

**2.5.2 Exclusion Criteria:** Subject shall be excluded from the study who are

- Individuals with pre-existing illnesses such as congenital cardiovascular problems, advanced malignant neoplastic disorders that are unrelated to environmental exposures,
- or who cannot do spirometry exercises.

### 2.6 Questionnaire Design

An inclusive, systematic interview schedule was used which incorporated validated modules from the WHO Occupational Health Assessment Toolkit and the American Thoracic Society respiratory questionnaire (ATS-DLD-78).

### 2.7 Validity and Reliability

The dependability of the tool was tested by Cronbach's Alpha (α) and it was 0.88 which demonstrates strong reliability and the face & content validity achieved by submitting to the professionals of the field including Public Health officer, epidemiologist & environmental health specialists.

### 2.8 Ethics Approval

Approval was taken from Institutional Ethics Committee (IEC). Local administrative and health authorities of Alwar were also approached and permission was obtained. Physical screening and data collection were initiated after obtaining Informed Consents in their local language (Hindi Language) from the participants.

## 3. Data Analysis

Statistical analysis was conducted using the SPSS program version 27.0.

- **Application of Descriptive Statistics analysis:** Frequencies, percentages, means and standard deviations
- **Inferential Bivariate Tests:** Chi-square ($\chi^2$) analysis is used to identify relationships. Physiological means were compared between exposure groups using independent samples t-tests and One-way ANOVA.
- **Advanced Multi-variable Modeling:** The Multiple Linear Regression to assessed continuous health outcomes, Binary Logistic Regression calculated Adjusted Odds Ratios (aOR) and 95% Confidence Intervals (CI) used to isolate independent predictors of health deprivation, for confounding factors like age and smoking status of the participants.

## 4. Results

### 4.1 Prototype of Socio-Demographic Characteristics

The demographic characteristics of the participants are shown in Table 1. The group is mainly male (62.0%) and concentrated in prime working-age groups (31–45 years, 43.0%).

Significantly, 61.0% of the sample is directly working in high exposure industrial sectors, with a split between mining (33.0%) and factory manufacturing (28.0%). Literacy analysis reveal a significant proportion with formal schooling (27.6% illiterate) yet tobacco usage is prevalent with 32.4% active smokers.

**Table 1:** Socio-Demographic Profile of the Study Population (N=500)

| Socio-Demographic Profile | Stratification Levels | Frequency (n) | % |
|---|---|---|---|
| Age groups (years) | 18–30 | 142 | 28.4 |
| | 31-45 | 215 | 43.0 |
| | 40-60 | 118 | 23.6 |
| | >60 | 25 | 5 |
| Biological Sex | Male | 310 | 62.0 |
| | Female | 190 | 38.0 |
| Principal Occupation | Mining/Quarrying | 165 | 33.0 |
| | Factory Production Industrial | 140 | 28.0 |
| | Agriculture / agricultural | 105 | 21.0 |
| | Unemployed / Home / Service | 90 | 18.0 |
| Literacy Status | Unable to read | 138 | 27.6 |
| | Basic Education | 172 | 34.4 |
| | Second education | 124 | 24.8 |
| | Higher Secondary & Above | 66 | 13.2 |
| How much do you smoke | Now a Smoker | 162 | 32.4 |
| | Ex- smoker | 58 | 11.6 |
| | Never Smoked | 280 | 56.0 |

### 4.2 Profiles of Environmental Proximity

Table 2 examines this in terms of residential distance to active industrial or mining sites. More than one-third (37.6%) reside relatively proximate (<1 km) and an additional 32.4% live between 1.1 and 3.0 km away, showing high baseline community exposure to ambient industrial/ mining pollution.

**Table 2:** Residential proximity to industrial/mining hotspots

| Spatial Exposure Factors | Distance Type | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Close to Active Clusters | <1 mile | 188 | 37.6 |
| | 1.1–3.0 km | 162 | 32.4 |
| | 3.1–5.0 km | 95 | 19.0 |
| | >5.0 km | 55 | 11.0 |

### 4.3 Dynamics of Occupation and Safety Parameters

**Table 3:** Daily Durations of Work Shifts

| Work Load Parameter | Class of Duration | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Working Hours Per Day | <8 Hours | 112 | 22.4 |
| | 8–10 Hours | 248 | 49.6 |
| | >10 Hours | 140 | 28.0 |

Table 3 Long working hours Almost half (49.6%) have usual 8-10 hours work daily, while 28.0% face long working hours greater than 10 hours daily.

Table 4 shows that the vast majority of people (79.0%) had been working in their respective field for more than 5 years, with 42.0% for more than 10 years of employment. Therefore, they clearly give the insight about chronic health hazards.

**Table 4:** Total Years of Occupational Experience

| Measures of Seniority | Levels of Span | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Years in service | <5 Years | 105 | 21.0 |
| | 5–10 Years | 185 | 37.0 |
| | 11–20 Years | 142 | 28.4 |
| | >20 Years | 68 | 13.6 |

Table 5 results indicate a serious safety problem in the workplace environment. More than half of the participants (54.4%) reported that they have no availability or they do not use personal protective equipment (such as dust mask, goggles) while at work, and only 16.4% report compliance.

**Table 5:** Compliance Rates of Personal Protective Equipment (PPE)

| Safety Index | Compliance Status | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Frequent Use of PPE | Reliable Compliance | 82 | 16.4 |
| | Intermittent / Partial | 146 | 29.2 |
| | Absence of Use | 272 | 54.4 |

### 4.4 Mapping of Multi-Systemic Clinical Morbidity

Table 6 showed the common respiratory problems among all participants. Exertional dyspnoea (shortness of breath) is the most common symptom (36.8%), followed by chronic productive cough (33.6%). This shows significant pulmonary distress in the participants.

**Table 6:** Prevalence of Self-Reported Symptoms of Respiratory Pathology

| Clinical Features | State | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Persistent Productive Cough | Present | 168 | 33.6 |
| | Absent | 332 | 66.4 |
| Exertional Dyspnea (SOB) | Present | 184 | 36.8 |
| | Absent | 316 | 63.2 |
| Wheezing / Chest Tightness | Present | 112 | 22.4 |
| | Absent | 388 | 77.6 |

Table 7 show that participants (19.6%) suffer from contact dermatitis, pruritus and industrial skin rashes, which are the result of direct contact with irritants or harsh industrial dusts.

**Table 7:** Prevalence of Dermatological Conditions

| Cutaneous Pathology | Status | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Contact Dermatitis / Rashes | Present | 98 | 19.6 |
| | Absent | 402 | 80.4 |

Chronic lower back pain as shown in Table 8 is one of the common problems experienced in our population (38.2%) due to excessive physical exertion, poor ergonomics and standing for a long time.

**Table 8:** Prevalence of Musculoskeletal Disorders (MSDs)

| Ergonomic Consequence | Status | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Chronic Low Back Pain | Present | 191 | 38.2 |
| | Absent | 309 | 61.8 |

In Table 9, one out of four individuals in the sample have reported chronic conjunctival redness which arises due to constant exposure to PM and toxic fumes.

**Table 9:** Ocular Irritation Manifestations

| Ophthalmological Vector | Status | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Chronic Conjunctival Redness | Present | 126 | 25.2 |
| | Absent | 374 | 74.8 |

As described in Table 10, 14.8% of the respondents have reported subjective hearing loss which is strongly related to absolute noise pollution from the industrial machines, stone crushers and drills.

**Table 10:** Prevalence of Auditory Deficits

| Ontological Manifestation | Status | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Subjective Hearing Loss | Present | 74 | 14.8 |
| | Absent | 426 | 85.2 |

### 4.5 Bivariate Inferential Hypotheses Testing

From Table 11, we can see that mining employees have the highest proportion (41.2%) of respiratory illness followed by the industrial/factory employees (31.4%). However, agricultural and service employees have much lower proportions (11.4% and 8.9% respectively). The Chi-square value ($\chi^2 = 32.14$, $p<0.001$) confirms that these differences are highly statistically significant and establish a clear correlation between heavy employment in the industrial/mining units and respiratory diseases.

**Table 11:** Analysis of Primary Occupation vs. Respiratory Dysfunctions

| Occupational Group | Respiratory Syndrome (+) | Respiratory Syndrome (-) | Total | Statistical Analytics |
|---|---|---|---|---|
| Mining / Quarrying | 68 (41.2%) | 97 (58.8%) | 165 | $\chi^2 = 32.14$ |
| Industrial Factory | 44 (31.4%) | 96 (68.6%) | 140 | df = 3 |
| Agrarian / Farming | 12 (11.4%) | 93 (88.6%) | 105 | p<0.001 |
| Service / Unemployed | 8 (8.9%) | 82 (91.1%) | 90 | Highly Significant |

Table 12 uses an independent samples t-test to compare objective lung function (Forced Vital Capacity) across exposure groups. There is also significantly reduced mean FVC (3.12 L) in the industrial/mining unit as compared to the non-industrial unit (3.68 L). The test statistic t (498) = -8.14, $p<0.001$ firmly rejects the null hypothesis (H0), and indicates that the long-term industrial and mining workers is related to measurable decrease in pulmonary volume.

**Table 12:** Independent Samples t-test for Physiological Lung Function Measures

| Physiological Marker | Occupational Grouping | Mean Metric | Std. Dev (±) | t-value | df | p-value |
|---|---|---|---|---|---|---|
| Forced Vital Capacity (FVC, L) | Industrial / Mining (n =305) | 3.12 | 0.45 | -8.14 | 498 | <0.001 |
| | Non-Industrial (n=195) | 3.68 | 0.52 | | | |

Table 13 applies a One-way ANOVA to evaluate how residential proximity to industrial clusters relates to Systolic Blood Pressure (SBP). Those individuals living nearest to the hazardous zones (<1km) have higher mean SBP (134.2 mmHg), there is also a significant decrease in pressure as the distance from industrial zones increases. The obtained F-ratio (14.23, p<0.001) shows that the relation between the residing proximity to the industrial zones and increased blood pressure is significant.

**Table 13:** One-Way ANOVA Evaluating Proximity and Systolic Blood Pressure Spikes

| Proximity Category | Sample Size (n) | Mean SBP (mmHg) | Std. Error | F-ratio | Significance (p) |
|---|---|---|---|---|---|
| <1 km | 188 | 134.2 | 1.12 | 14.23 | <0.001 |
| 1.1–3.0 km | 162 | 129.5 | 0.98 | | |
| 3.1–5.0 km | 95 | 124.1 | 1.34 | | |
| >5.0 km | 55 | 121.8 | 1.56 | | |

### 4.6 Advanced Multi-variable Logistic Regression Modeling

According to Table 14, after controlling for age and smoking, workers in mining and quarrying are at huge risk; almost fivefold greater chance of acquiring a respiratory illness (aOR = 4.82, 95% CI: 2.91-7.96, p<0.001). In addition to that, lack of personal protective equipment (PPE) is also an important risk factor for illness, it increases the chances of illnesses by four times (aOR = 4.12); while living near 1 km to industrial locations increases the respiratory illness chances by two folds (aOR = 2.74).

**Table 14:** Predictors of Respiratory Morbidity (Binary Logistic Regression)

| Risk Predictor Variable | Crude OR | Adjusted OR (aOR) | 95% Conf. Interval (CI) | p-value |
|---|---|---|---|---|
| Age (>45 Years vs. Base) | 1.85 | 1.62 | 1.12–2.34 | 0.012 |
| Mining / Quarry Labor | 5.24 | 4.82 | 2.91–7.96 | <0.001 |
| Residential Proximity<1 km | 3.12 | 2.74 | 1.65–4.55 | <0.001 |
| Absolute PPE Non-use | 4.85 | 4.12 | 2.45–6.92 | <0.001 |
| Smoking Status (Active) | 2.45 | 2.01 | 1.32–3.08 | 0.002 |

From Table 15, it is evident that long daily work hours (greater than 10 hours) are strongly associated with musculoskeletal conditions, which raise the chances of developing chronic pain by more than three times (aOR = 3.42, p<0.001), showing the strong physical effects of long structural strain.

**Table 15:** Odds Ratios for Developing Musculoskeletal Manifestations

| Risk Predictor Variable | Adjusted OR (aOR) | 95% Conf. Interval (CI) | Significance (p) |
|---|---|---|---|
| Daily Shift >10 Hours | 3.42 | 2.11–5.54 | <0.001 |
| Years of Labor >10 Years | 2.15 | 1.34–3.45 | 0.004 |

The results from Table 16 show that those who directly use raw chemicals or unmitigated industrial dust are almost 3 times as likely to experience dermatological issues (aOR = 2.94; p<0.001), indicating the need for improved skin protection and hygiene in these industries.

**Table 16:** Logistic Regression Determinants for Dermatological Conditions

| Risk Predictor Variable | Adjusted OR (aOR) | 95% Conf. Interval (CI) | Significance (p) |
|---|---|---|---|
| Direct Chemical / Dust Handling | 2.94 | 1.72–5.02 | <0.001 |

Table 17 estimates the collective risks, and it is noted that the cardiovascular risk is almost four times higher (aOR = 3.88) in older age (>45 years) group, with a very close proximity (<1 km) to industrial centers, indicating that environmental pollution compounding with normal aging process increase their systemic susceptibility.

**Table 17:** Multi-variable Risk Coefficients for Cardiovascular Symptoms

| Risk Predictor Variable | Adjusted OR (aOR) | 95% Conf. Interval (CI) | Significance (p) |
|---|---|---|---|
| Proximity<1 km + Age >45 | 3.88 | 2.04–7.36 | <0.001 |

Table 18 reveals that the use of basic safety eyewear is a highly preventable safety issue as the risk of chronic ocular inflammation is more than 4 times greater in manufacturing situations where basic safety eyewear is not used (aOR = 4.18).

**Table 18:** Determinants of Ocular Irritation Odds

| Risk Predictor Variable | Adjusted OR (aOR) | 95% Conf. Interval (CI) | Significance (p) |
|---|---|---|---|
| Absolute Absence of Eye Protection | 4.18 | 2.54–6.88 | <0.001 |

Table 19 results indicate that there is a strong association between being exposed to all workplace noise and having an increased odds of hearing loss (aOR = 5.12) when working near heavy stone crushers and drilling area as, allowing for a conclusion of a relationship between one or more of the noise sources and complete workplace noise.

**Table 19:** Risk Analysis for Subjective Auditory Morbidity

| Risk Predictor | Adjusted OR (aOR) | 95% Conf. Interval (CI) | Significance (p) |
|---|---|---|---|
| Crusher/Drill Proximity | 5.12 | 2.88–9.10 | <0.001 |

### 4.7 Predictive Linear Regression Architectures

The results in Table 20 indicate a good correlation ($R^2$ = 0.441, p<0.001) between systemic health degradation score and the overall results. Daily shift duration is the most important predictor (β = 0.34, p<0.001) followed closely by the residential proximity to industrial zones (β = -0.29, p<0.001), indicating that longer working hours and living close to industrial areas are significant factors affecting systemic health associated complication.

**Table 20:** Stepwise Multiple Linear Regression to Predict Systemic Health Degradation Scores

| Predictor Variable | Unstandardized B | Std. Error | Beta (β) | t-value | Significance (p) |
|---|---|---|---|---|---|
| Constant | 12.45 | 1.84 | — | 6.76 | <0.001 |
| Daily Shift Duration (Hours) | 2.84 | 0.42 | 0.34 | 6.75 | <0.001 |
| Residential Proximity Index | -3.12 | 0.54 | -0.29 | -5.77 | <0.001 |
| Total Years of Employment | 0.64 | 0.14 | 0.21 | 4.57 | <0.001 |

### 4.8 Visual Epidemiology (Analytical Charts)

Figure 2 reveals that distribution of respiratory function impairment, as measured by Forced Vital Capacity (FVC) according to different industrial groups is clearly showing a decrement in lung capacity for the worker population grouped in those categories with high exposure.

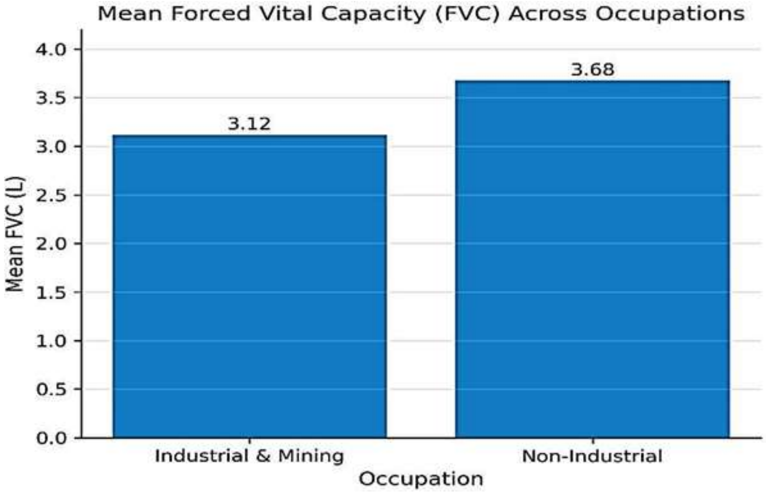


**Figure 2:** Respiratory Function Impairment

The prevalence of chronic symptoms is consistently related to a decrease in lung capacity among the study subjects in Figure 3. The spread of these health issues indicates the depth and breadth of respiratory and musculoskeletal tension.

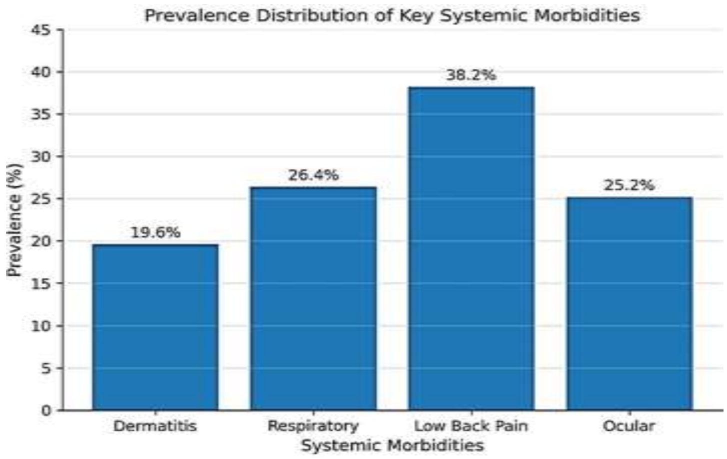


**Figure 3:** Decline Lung Capacity

## 5. Discussion

The combined effect of ambient environmental degradation with hazardous occupational environments in Alwar District, Rajasthan are clearly indicated from this cross-sectional analytical assessment result. The main objective was to find the occurrence of multi-systemic illnesses within this population. The data indicates that there is a high prevalence of health issues, mainly of respiratory (26.4%), musculoskeletal (38.2%) and chronic eye irritation (25.2%). These results are consistent with the local environmental monitoring data indicating that the country and international safety limits are normally violated in Alwar city, which is attributed to the dust and emission from the industrial clusters in the region.

The inferential Statistic heavily confirmed the basic hypotheses. Forced Vital Capacity (FVC) was found to be statistically significantly lower in the industrial and mining laborers (3.12 L) than in the non-industrial workers (3.68 L, $p<0.001$) by using independent samples t-test. These declines in lung function indicate that the crystalline silica dust has caused more advanced changes in lung tissue, possibly in the early stages of lung fibrosis or chronic obstructive diseases, due to exposure over time.

The findings are supported well by the previous research, as seen in Hamanaka and Mutlu (2025) which correlated exposure to fine particles with measurable decreases in lung capacity and increases in cardiorespiratory strain. The patterns are similar to work by experts in the region who identified similar respiratory susceptibilities among sandstone quarry workers in Jodhpur and Nagaur in Rajasthan [6].

Moreover, our stepwise multiple linear regression model showed that environmental exposure and occupational demands are associated with the character long-term health outcomes ($R^2 = 0.441$ $p<0.001$). The greatest single predictor of systemic health issues was daily shift length ($\beta = 0.34$), with proximal residential exposure to active industrial sites coming in second at -0.29. This illustrates that health hazards are not just confined to the workplace: living in an industrial area causes a continual background exposure of daily work hazards. In multi-variable logistic regression, safety compliance was again identified as a key factor. Workers entirely lack in access to or failing to use regular personal protective equipment (PPE) handled more than four times the odds of developing respiratory illnesses (aOR = 4.12, 95% CI: 2.45-6.92). The total rate of absolute non-use of basic safety measures (54.4%) indicates a significant lack of basic safety measures at work in Alwar's unorganized industrial sectors and points to the need for intervention and upscale implementation of basic safety measures on the job.

## 6. Public Health Implications

This study has implications for local health policy and environmental management in the state of Rajasthan. They demonstrate that to consider the areas of occupational health and community environmental tracing separately leads to a false impression of the overall disease burden. To account for low-level chronic exposures that extend from industrial areas to neighbouring regions, public health frameworks should be familiarized.

Primary health centers (PHCs) in industrial towns and cities like Alwar and Bhiwadi should have analytical equipment including digital spirometry and targeted radiological screening system as respiratory and musculoskeletal illness are the most dominant among disorganized workers. It is essential to implement these advances to identify the more advanced occupational diseases, such as silicosis, in early stages so that it can be managed in time before it becomes irreversible.

## 7. Recommendations

- Implement compulsory use of wet drilling methods and mechanised water sprinkling systems in all open cast mines and stone crushing areas in Alwar to reduce ambient respirable silica dust.
- Strict Use of PPE: Institute strict governing penalties for industrial operators who fail to make provisions for standard high efficiency particulate masks, protective eyewear and ergonomic provision to their workers.

- Establish Specialized Occupational Health Clinics: Establish occupational health clinics in local government hospitals of Alwar with a focus on regular monitoring of lung function, cardiovascular status and early detection of pneumoconiosis.
- Establishing Fixed Buffer Zones: Serve as a strict zoning that will instruct a green buffer zone of at least 1.5 km to 2 km between new industrial divisions and residential areas, to minimize the community's exposure to pollution.

## 8. Conclusion and Limitations

The findings of this study validate that exposure to environmental deprivation and unsafe occupational conditions & practices are both contributing factors that trigger serious multi-systemic diseases in Alwar District, Rajasthan. Respiratory, musculoskeletal and eye disorders are prevalent and lung function has been clearly decreased in the mining, quarrying and industrial unit workers in the region. The combined effect of these specific workplace risks is heightened by the high level of community exposure to these risks for people who live near an active industrial site. This public health challenge necessitates a coordinated response and implementation of tighter emission limits on environmental emissions, workplace safety regulations and accessible, specialized occupational healthcare monitoring throughout the region.

The present study was cross sectional design, which is limited to make an absolute direct causal relation for time. Moreover, self-reported symptom data may present recall bias. The sample size of 500 is appropriate for Alwar District but if the sample size is increased to longitudinal across multiple industrial area, it will be able to give wider insight on these health matters.

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## References

1. Hussain, M. (2024). Impact of urbanization on environment and health role of different environmental sensors. In *Sensors for Environmental Monitoring, Identification, and Assessment* (pp. 333-358). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-1930-7.ch020
2. Loeb, E., Zock, J. P., Miravitlles, M., Rodríguez, E., Kromhout, H., Vermeulen, R., ... & Ferrer Sancho, J. (2024). Occupational exposures, chronic obstructive pulmonary disease and tomographic findings in the Spanish population. *Toxics*, *12*, 689. https://doi.org/10.3390/toxics12100689
3. Fuller, R., Landrigan, P. J., Balakrishnan, K., Bathan, G., Bose-O'Reilly, S., Brauer, M., ... & Yan, C. (2022). Pollution and health: a progress update. *The Lancet Planetary Health*, *6*, e535-e547. https://doi.org/10.1016/S2542-5196(22)00090-0

4. Asri, A. K., Pan, W. C., Lee, H. Y., Su, H. J., Wu, C. D., & Spengler, J. D. (2021). Spatial patterns of lower respiratory tract infections and their association with fine particulate matter. *Scientific Reports*, *11*, 4866. https://doi.org/10.1038/s41598-021-84435-y
5. Nandi, S., Burnase, N., Barapatre, A., Gulhane, P., & Dhatrak, S. (2018). Assessment of silicosis awareness among stone mine workers of Rajasthan state, *Indian Journal of Occupational and Environmental Medicine*, *22*, 97-100. https://doi.org/10.4103/ijoem.ijoem_63_18
6. Hamanaka, R.B. and Mutlu, G.M. (2025). Particulate matter air pollution: effects on the respiratory system, *Journal of Clinical Investigation*, *135*, e194312. https://doi.org/10.1172/jci194312