REVIEW ARTICLE

Air Pollution and Chronic Respiratory Diseases (CRDs) in Rajasthan: A Systematic Review of the Literature

Pranali Ahir, Dinesh Singh Bhati, Suresh Yadav
Department of Biochemistry, ICMR–NIIRNCD, Jodhpur, Rajasthan, India

CORRESPONDING AUTHOR
Dr. Pranali Ahir, Scientist (Medical), Biochemistry, National Institute for Implementation Research on Non-Communicable Diseases, Jodhpur-342005 - Rajasthan
Email: drpranalib4@gmail.com

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ABSTRACT
Background: In Rajasthan, ambient, indoor, and occupational exposures overlap across diverse agro-climatic and mining zones, contributing to chronic respiratory diseases (CRDs) from dust, vehicular pollution, and biomass burning. **Aims and objectives**: To conduct an in-depth review of CRD burden, risk factors, and respiratory outcomes associated with ambient, occupational, and indoor air pollution in Rajasthan. **Methodology**: The systematic review followed the PRISMA 2020 guidelines and was registered in PROSPERO (CRD420251000552). We searched PubMed, Scopus, Google Scholar, Cochrane, EMBASE, and Web of Science up to 31 May 2025. 18 articles (1999–2025) were reviewed after 1,222 duplicates were eliminated and 353 complete texts were evaluated from 3,679 articles. The AXIS and Newcastle–Ottawa Scales assessed the quality of cross-sectional and cohort studies. Heterogeneity necessitated narrative synthesis. **Result**: Silicosis prevalence varied from 8% to 52%, silico-TB from 7% to 12%, and tuberculosis from 9% to 17%. Mine workers had restrictive spirometry, 40%–89%, and developed severe fibrosis, 22%. Silicosis/TB risk increased 5.61-fold in BMI <18.5. Traffic police with high RSPM had lower FEV_1, while exposure to biomass fuel was associated with elevated wheezing and reduced lung function. **Conclusion**: The comprehensive literature review first estimates a significant respiratory burden and identifies gaps in longitudinal, cohort, and case-control studies with exposure monitoring, demographic (geriatric, paediatric), and advanced radiological techniques.

KEYWORDS
Air Pollution; Chronic Respiratory Disease; Occupational Exposure; Silicosis; Tuberculosis; Biomass; Particulate Matter; Spirometry; Respiratory Function Tests; Rajasthan.

INTRODUCTION
In India, 61% of CRD-related mortality is attributed to air pollution. Occupational factors contribute 17% of global CRD deaths, 26% in India, and 33% in Rajasthan.—figure 1. (1)A decade-long rise in COPD-related mortality due to ozone was 25%. Asthma prevalence was 3.4%, COPD 3.1%, allergic rhinitis/bronchitis 4–7%, and chronic respiratory disease (CRD) 8.1%—figure 2. (1).

Figure 1: Respiratory disease burden prevalence across the globe, India and Rajasthan (1)

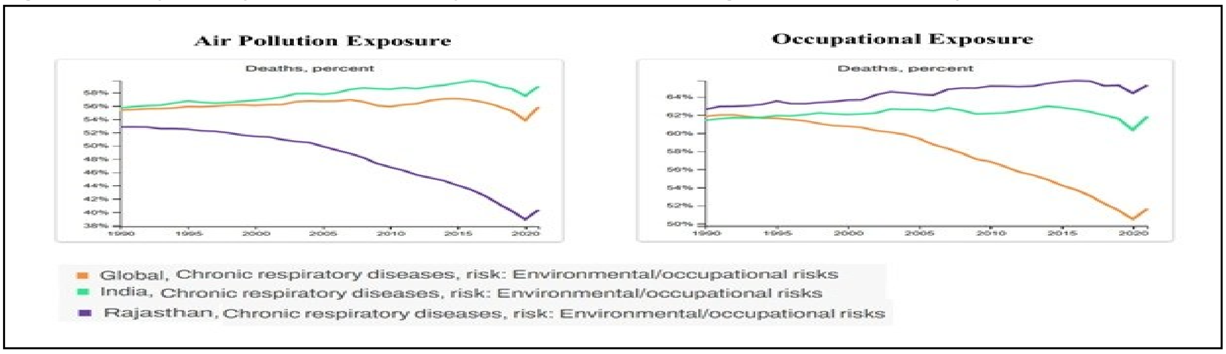
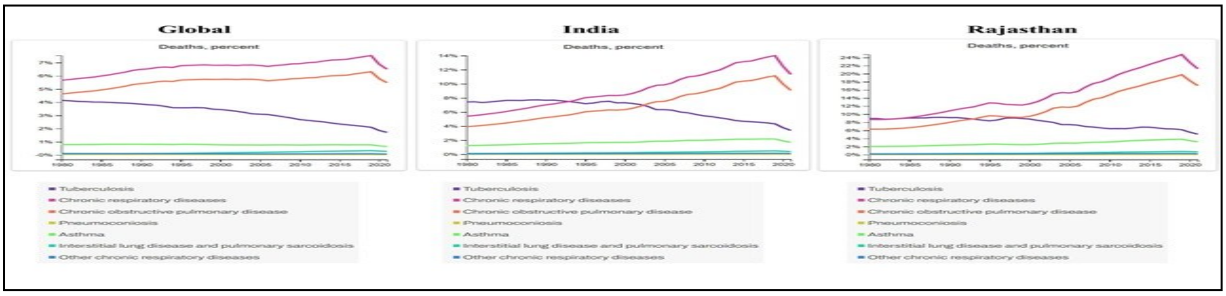


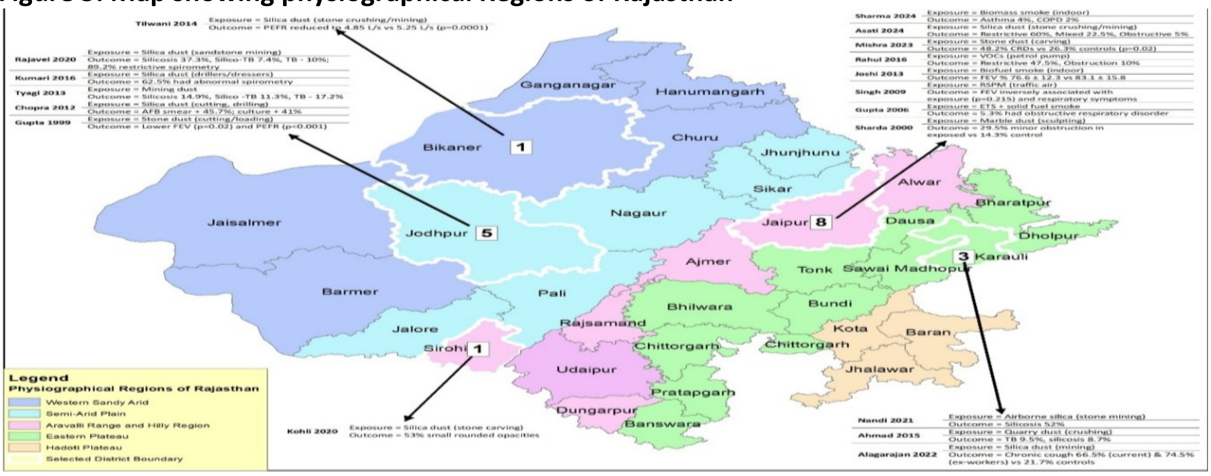
Figure 2: Respiratory disease burden: Deaths across the globe, India and Rajasthan (1)



The figure 1 presents trends in deaths (%) attributable to chronic respiratory diseases due to air pollution exposure and occupational exposure from 1990 to 2020 across global, India, and Rajasthan levels. The figure 2 illustrates trends in respiratory disease mortality across the global level, India, and Rajasthan from 1990 to 2020. Globally, CRDs and COPD show a gradual increase, while TB declines. India experiences a sharper rise in CRDs/COPD with declining TB, whereas Rajasthan shows the highest increase and slower TB reduction, along with greater occupational disease contribution.

Rajasthan's diverse physiography ranges from the Thar Desert to the Aravalli hills, and it experiences climatic extremes.(2). Traffic police, biomass fuel cooks, miners, and urban inhabitants exposed to high particulate matter are vulnerable. Occupation, rural/urban dwellings, and fuel consumption affect exposure. Rural households still used biomass fuel (NFHS-5), two-wheeler and thermal power generation increased ambient pollution. (3)(4)urbanisation patterns and expected urban expansion exacerbate the risk of exposure(5). Policy and monitoring frameworks are also available.(6). Local exposure assessment is limited by monitoring gaps and pollutant coverage. Occupational air pollution, ambient and indoor air pollution, climatic variability, and low monitoring led to a full literature review to compile region-specific research. (Figure 3)

Figure 3: Map showing physiographical Regions of Rajasthan



The figure 3 illustrates the distribution of exposure and associated health outcomes reported across multiple studies conducted in different districts of Rajasthan, representing diverse physiographical regions of the state.

Aims & Objectives

1. To estimate CRD prevalence linked to ambient, occupational, and household air pollution in Rajasthan.
2. To identify key pollutants, exposure sources, and high-risk groups.
3. To summarise spirometric, radiological, and clinical outcomes.
4. To identify geographic and methodological gaps and propose research priorities.

Material & Methods

Study Design: This systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020(7). The data were synthesised from previous studies; hence, no ethical approval or patient consent was required. Our protocol was registered in the International Prospective Register of Systematic Reviews. software (PROSPERO-CRD420251000552).

Study Setting: Studies from Rajasthan, covering mining areas, hospitals, community surveys, traffic pollution, petrol stations, and rural households. Geographic regions included the Aravalli Range, Eastern Semi-arid Plain, Eastern Plain, and Sandy Arid Western zone.

Study Population: The population included Rajasthan residents of all ages and genders, including sandstone miners, quarry workers, marble sculptors, traffic police, petrol pump attendants, biomass fuel users, and pregnant women exposed to polluted environments.

Study Duration: Studies published from 1999 to 31 May 2025 were included. Database searching was completed up to 31 May 2025.

Working Definition: CRDs included asthma, COPD, silicosis, silico-tuberculosis, tuberculosis, interstitial lung disease, and pleural disorders diagnosed clinically, spirometrically, or radiologically. Restrictive spirometry was defined as reduced FVC or FEV_1 below predicted. Obstructive spirometry was defined as FEV_1/FVC ratio <0.70. Air pollution included ambient, occupational, and household sources.

SEARCH SOURCE & STRATEGY: We precisely searched various renowned databases (PubMed, Scopus, Google Scholar, Cochrane, Embase, Web of Science, and other journals) for English-language research articles published up to May 31, 2025. We used the search terms "air pollution," "COPD," "asthma," "silicosis," "tuberculosis," and "Rajasthan", and the PECO framework for assessment (Tables 1& 2).

Table 1 Search Term to detect studies related to Air Pollution and Chronic Respiratory Diseases in Rajasthan

Search Name	Source	Query
Search for the term to identify studies on air pollution and chronic respiratory diseases in Rajasthan.	PubMed	("air pollution"(MeSH) OR "ambient air pollution" OR "indoor air pollution") AND ("chronic respiratory diseases"(MeSH) OR "COPD" OR "asthma" OR "chronic bronchitis" OR "silicosis" OR "tuberculosis"(MeSH) OR "interstitial lung disease"(MeSH)) AND ("India"(MeSH) OR "Rajasthan")
	Scopus	TITLE-ABS-KEY (("air pollution" OR "ambient air pollution" OR "indoor air pollution") AND ("chronic respiratory disease*" OR "COPD" OR "asthma" OR "chronic bronchitis" OR "silicosis" OR "tuberculosis" OR "interstitial lung disease") AND ("India" OR "Rajasthan"))
	Web of Science	TS= ("air pollution" OR "ambient air pollution" OR "indoor air pollution") AND TS= ("chronic respiratory disease*" OR "COPD" OR "asthma" OR "chronic bronchitis" OR "silicosis" OR "tuberculosis" OR "interstitial lung disease") AND TS= ("India" OR "Rajasthan")
	EMBASE	('air pollution'/exp OR 'ambient air pollution' OR 'indoor air pollution') AND ('chronic respiratory disease'/exp OR 'COPD'/exp OR 'asthma'/exp OR 'chronic bronchitis'/exp OR 'silicosis'/exp OR 'tuberculosis'/exp OR 'interstitial lung disease'/exp) AND ('India'/exp OR 'Rajasthan')

Cochrane Library	("air pollution" OR "ambient air pollution" OR "indoor air pollution") AND ("chronic respiratory disease*" OR "COPD" OR "asthma" OR "chronic bronchitis" OR "silicosis" OR "tuberculosis" OR "interstitial lung disease") AND ("India" OR "Rajasthan")
Google Scholar	("air pollution" OR "ambient air pollution" OR "indoor air pollution") AND ("chronic respiratory disease" OR "COPD" OR "asthma" OR "chronic bronchitis" OR "silicosis" OR "tuberculosis" OR "interstitial lung disease") AND ("India" OR "Rajasthan")

Table 2 Search strategy to detect studies related to Air Pollution and Chronic Respiratory Diseases in Rajasthan

	PECO Category	Related to	Search strategy
Search strategy to detect studies related to Air Pollution and Chronic Respiratory Diseases in Rajasthan	Population	Characteristics	Rajasthan residents of all ages, genders, urban and rural, from hospitals, medical colleges, and the population.
	Exposure	Air Pollutant type criteria	Source, type, and confounding factors lead to indoor and ambient air pollution.
		Pollutant type	Particulate matter (PM_{10}, $PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), ammonia (NH_3), lead (Pb), benzene, volatile organic compounds (VOCs)
		Location	Indoor and ambient air pollution, urban vs. rural, physiographic regions of Rajasthan
	Comparator or Control	Similar studies	Rajasthan air pollution and CRD prevalence studies compared to other low-pollution Indian regions.
	Outcomes	Disease or indicator	Chronic respiratory diseases (CRDs): asthma, COPD, interstitial lung disease, tuberculosis, silicosis, fibrosis, pleural disorder, pneumothorax,
		Severity impact assessment criteria's	Direct health impact: Pulmonary lung function, investigation outcome, Prevalence, respiratory symptoms, mortality, DALYs
		Clinical benefit	Risk factor identification, CRD epidemiological trends in Rajasthan
	Study Design		Cross-sectional, cohort, case-control, Observational, epidemiological studies

Eligibility Criteria (Inclusion/Exclusion)

We conducted an extensive review of population-based, peer-reviewed studies in Rajasthan on air pollution and chronic lung diseases among people of all ages and sexes, using the PECO framework. Each author independently validated the inclusion and exclusion criteria before the final decision. (Table 3)

Table 3: Inclusion and Exclusion Criteria to detect studies related to Air Pollution and Chronic Respiratory Diseases in Rajasthan

PICO(S) Component	Inclusion Criteria	Exclusion Criteria
Population (P)	Residents of all ages and genders within the four physiographic regions of Rajasthan.	Studies not including Rajasthan residents.
Exposure (E)	Studies with indoor and Ambient air pollution, duration of exposure, source of pollutant, type of pollutant and confounding factors	Research not in English. Air pollution and CRD results were not studied. The modelling research lacked empirical measurements.
Comparator(C)	Studies comparing Rajasthan's air pollution levels and CRD prevalence with other low-pollution regions in India.	Studies without a comparative element. Studies that do not analyse air pollution in relation to CRD prevalence.
Outcome (O)	Research on the prevalence, severity, or risk factors of CRDs associated with air pollution; studies analysing	Studies focusing exclusively on acute respiratory infections.

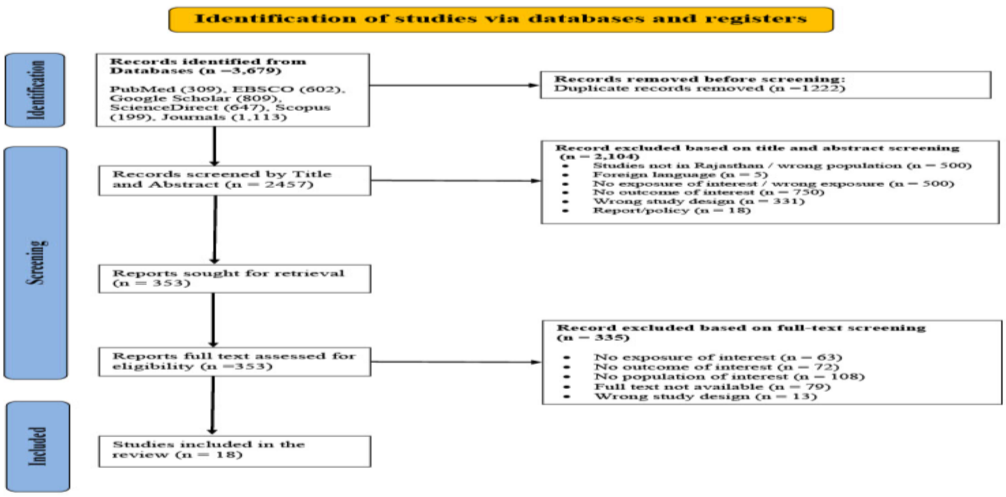
	lung function impairment, symptom aggravation, hospitalisation rates, or DALYs, YLL, YLD, mortality from CRDs.	Studies that lack data on CRD-related impacts on health. - Studies that don't involve air pollution exposure associated with CRD outcome.
Study Design (S)	We assessed population-based studies that analysed direct impacts on health, covering epidemiological, case-control, retrospective, cross-sectional, comparative, and prospective and retrospective cohort studies conducted within observational study frameworks.	Research that does not directly support the SLR goal. RCTs are qualitative, experimental, implementation research focusing on treatments rather than exposure outcomes. Conference proceedings, review articles, and unpublished papers. Animal experiments, pharmaceutical development, and fundamental laboratory-based scientific research did not involve humans; only environmental sampling was studied.

DATA SYNTHESIS & EXTRACTION PROCESS: All retrieved studies were de-duplicated using Mendeley and PubMed. Screening was conducted in two phases. First, PA and DB independently reviewed titles and abstracts and excluded irrelevant studies with documented reasons. Second, full-text assessment was performed by PA, DB, and SY to confirm eligibility. Data extracted included study design, participant characteristics, CRD definitions, exposure sources, pollutant measures, lung function outcomes, radiological findings, symptoms, and risk groups. Extraction and synthesis were managed using Microsoft Excel and Rayyan (free version).

Results

The PRISMA flow diagram (Figure 4) A total of 3,679 records were retrieved from PubMed (309), EBSCO (602), Google Scholar (809), ScienceDirect (647), Scopus (199), and journals (1,113). After removal of 1,222 duplicates, 2,457 titles and abstracts were screened. Full-text evaluation was performed for 353 studies. A total of 335 were excluded due to a lack of exposure assessment, inadequate results, an incorrect population, unavailable full text, or an incorrect study design. Finally, 18 studies were included.

Figure 4: PRISMA flow diagram (7)



QUALITY ASSESSMENT: The AXIS tool and the Newcastle–Ottawa Scale were used to evaluate the study results, with two unbiased reviewers scoring on 20-point and 10-point criteria for cross-sectional and cohort designs (8,9). The 16 studies were primarily cross-sectional (10–25). AXIS cross-sectional studies scored 8–15 for quality. Figure 5 Twelve of sixteen research failed to justify their sample size

(10,11,12,13,14,15,17,18,19,20,22,24). The sample frame has been surpassed by recent investigations (10,11,12,13,14,15,17,18,19,20,21,22,23). The 16 studies had no dropouts. Some research did not define hypotheses,statistical analysis (10,11,14,20,21). Limitations were missed in a few studies (10,11,14,16,17,25). Many studies lacked financial support, conflict of interest disclosures, ethical approval, and informed consent (10,11,13,15,16,17,19,21,20,24). Table 4 of the Newcastle-Ottawa Quality Assessment for Cohort studies: 2 prospective, 7 (26) retrospective, and 3 (27) research.

Figure 5: Showing quality scores ranged tool for Cross-Sectional Studies (AXIS tool) (8)

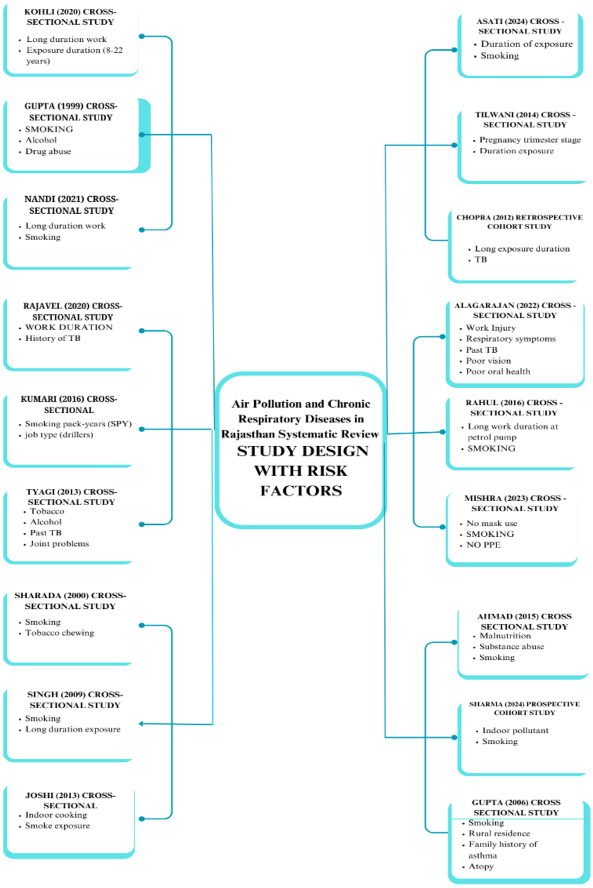
Answers: Yes / No (Yes = 1, No = 0)																
Questions	Joshi 2013	Rahul 2016	Rajavel 2020	Tyagi 2013	Nandi 2021	Asati 2024	TILWANI 2014	Alagarajan 2022	Sharda 2000	Gupta 1999	Ahmad 2015	Mishra 2023	Gupta 2006	Kumari 2016	Singh 2009	kohli 2020
Introduction																
1. Were the aims/objectives of the study clear?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Methodology																
2. Was the study design appropriate for the stated aim(s)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Was the sample size justified?	No	No	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4. Was the target/reference population clearly defined? (Is it clear who the research was about?)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Was the sample frame taken from an appropriate population base so that it closely represented the target population under investigation?	No	No	No	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No
6. Was the selection process likely to select participants that were representative of the target population under investigation?	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No	No	No
7. Were measures undertaken to address non-responders?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
8. Were the outcome variables measured appropriate to the aims of the study?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9. Were the outcome variables measured correctly using instruments/ measurements that had been trialled, piloted, or published previously?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10. Is it clear what was used to determined statistical significance and/or precision estimates? (e.g., p values, CIs)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
11. Were the methods (including statistical methods) sufficiently described to enable them to be repeated?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Results																
12.Were the basic data adequately described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13. Does the response rate raise concerns about nonresponse bias?	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	Yes
14. If appropriate, was information about non-responders described?	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
15. Were the results internally consistent?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
16. Were the results for the analyses described in the methods, presented?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Discussion																
17. Were the authors' discussions and conclusions justified by the results?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18. Were the limitations of the study discussed?	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	No	Yes
19. Were there any funding sources or conflicts of interest that may affect the authors' interpretation of the results?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
20. Was ethical approval or consent of participants attained?	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes	No
Score (out of 20)	13	13	14	11	13	14	14	12	8	10	13	15	15	15	14	13

Table 4 Newcastle-Ottawa Scale Cohort study

Category	Newcastle-Ottawa Scale Cohort study	Sharma 2024	Chopra 2012
Selection	1. Representativeness of the exposed cohort	☆	☆
	2. Selection of the non-exposed cohort	☆	-
	3. Ascertainment of exposure	☆	☆
	4. Demonstration that outcome of interest was not present at the start of the study	☆	-
Comparability	1. Comparability of cohorts based on the design or analysis controlled for confounders	☆	-
Outcome	1. Assessment of outcome	☆	☆
	2. Was the follow-up long enough for outcomes to occur	-	-
	3. Adequacy of follow-up of cohorts	☆	-

STUDY DESIGN AND RISK FACTOR: Most of the 18 study designs were cross-sectional, with only two cohort studies providing longitudinal insights. In a survey of 126 miners, 80% smoked and consumed illegal substances. Malnourished miners (BMI < 18.5) had a 5.61× higher risk of silicosis/TB (38%; 95% CI 1.87–16.78). Only 7% of 121 participants used masks, 37.3% exposed stone carvers, 31.5% controlled smoked, and >20% had >10 years of employment. 51.3 % of the 80 workers smoked moderately, 5% heavily, and 22.5% did not ($p = 0.004$). ETS prevalence: 46% non-smokers, 15.1% smokers; fuel use: LPG 16.4%, wood 0.7%, dung 4.8%, coal 11.1%. Sculptures had a more extended exposure period (17.75 ± 11.67 years) versus the other 15 ± 10.55 years ($p < 0.003$)(Figure 6).

Figure 6: Details of Risk Factor in cross-sectional and cohort PRISMA flow diagram



STATISTICS ANALYSIS: Figure 6 illustrates cross-sectional and cohort risk variables and statistics. A study of 80 stone mine workers in Jaipur found considerable symptom variance and a one-way ANOVA demonstrated lung function loss with prolonged silica exposure ($p<0.05$). In the 2nd and 3rd trimesters, pregnant women exposed to outdoor pollution had lower FVC, FEV_1, and FEF ($p\leq0.0001$). Atypical TB patients have more radiological abnormalities ($p<0.05$). Multivariate logistic regression proven mining-related morbidity. Workers at petrol pumps had lower spirometry indices ($p<0.05$). Malnutrition raised TB/silicosis risk (HR 5.61).

ASSESSMENT OF RESPIRATORY HEALTH OUTCOMES: We divided chronic respiratory health outcomes into restrictive respiratory disorders, obstructive respiratory disorders, radiologic findings, symptom exacerbation, and pulmonary dysfunction (Table 5).

A. Cross Sectional Studies

i) Restrictive respiratory disorder (Silicosis, Silico-Tuberculosis, Tuberculosis, Pneumothorax, pulmonary fibrosis)

In a cross-sectional study of 45 male stone carvers (mean age, 40) with 8–22 years of silica exposure, tiny round opacities were 53%, irregular 24.4%, profusion-1/1 48.9%, large 22.2%, calcified nodes 44.4%, emphysema 26.6%, mediastinal nodes 48.9%, pleural thickening 53.3%, and silico-tuberculosis 6.6%(20). Only 40 (7.5%) of the 529 PMF cases in Karauli and Dholpur had progressive massive fibrosis, while 275 (52%) had silicosis. Pulmonary tuberculosis was present in 9.4% (50/529), and 12.4% (66/529) had silico-tuberculosis. Work duration increased PMF and silicosis. 453 (85.6%) completed DOTS(22). Of the sandstone mine workers in Jodhpur, 37.3% had silicosis and 7.4% had silico-TB. 89.2% of subjects had abnormal (restricted) spirometry. Reticulonodular opacities were observed in 81% of abnormal chest X-rays among 42% of patients PMF was present in 22% of workers with mild nodular opacities(21). In Jodhpur, 221 mine workers had a silicosis rate of 14.9%, a silico-TB rate of 11.3%, and a tuberculosis rate of 17.2%.

Chronic respiratory infections were the most common diagnosis (21.3%), and 58.8% of workers reported having respiratory symptoms. Restrictive patterns were frequently observed in the lung function tests(14). In Sorya village, Jaipur, 126 miners had 9.5% TB (12/126) and 8.7% silicosis (11/126); chronic cough 43.7% (55/126), chest pain 47.6% (60/126), and dyspnoea 17.5% (22/126). Malnutrition (BMI<18.5) increased the risk of silicosis/TB by 5.61 times in 38% of cases ($p=0.047$; HR=5.61; 95% CI 1.88–16.78; $p=0.002$). risk was lower for non-substance use (HR=0.58; 95% CI 0.21–1.61; $p=0.298$)(17).

In Karauli, current and ex-mine workers had significantly worse symptoms than controls: A persistent cough in 66.5% and 74.5% vs. 21.7%, dyspnea in 54% and 74% vs. 15%, and wheezing in 31% and 53% vs. 8%; former mine workers had respiratory issues (31%), weakness (24%), and tuberculosis (20%)(23).

Table 5: Summary of finalised Study of SLR on Air pollution and chronic respiratory diseases in Rajasthan

AUTHOR NAME YEAR	STUDY LOCATION	STUDY DESIGN	STUDY POPULATION	EXPOSURE	OUTCOME	RESULT	CRD OUTCOME
R Asati · 2024	Department of Respiratory Medicine, Jaipur National University, Jaipur, Rajasthan	cross-sectional study.	Eighty male stone mine workers were admitted to the Department of Respiratory Medicine with a history of stone dust exposure and aged over 18 years.	Among 80 male workers (mean age 44.39 ± 8.9 years), the average exposure to stone dust was 16.68 ± 5.81 years (range 1–28). Duration of exposure: 6.25% (0-5 years), 17.50% (5-10 years), and 76.25% (≥10 years). Nonsmokers 22.5%, light 21.25%, moderate 51.25%, heavy 5.0%.	In 80 individuals, spirometry showed restrictive pattern in 60% (n = 48; FVC 2.41 ± 0.54 L, FEV1 2.02 L), mixed in 22.5% (n = 18; FVC 2.56 ± 0.63 L, FEV1 1.34 L), and obstructive in 5% (n = 4; FVC 3.09 ± 0.71 L, Exposure <1 year decreased lung function (FVC 3.90 ± 1.30 L; p = 0.00). Silicosis stage impacted FEV1 (acute: 2.20 ± 0.32 L; accelerated: 2.67 ± 0.16 L; chronic: 3.51 ± 0.29 L; p = 0.024). Breathlessness 93.75%, cough 63.75%, chest pain 51.25%, expectoration 8.75%, hemoptysis 7.5%, wheeze 5%.	Patients had dyspnea (93.75%), cough (63.75%), chest pain (51.25%), expectoration (8.75%), hemoptysis (7.5%), and wheeze (5%). Localised hypertrophy in 77.5%, diaphragmatic thickening in 76 (95%), costo-phrenic angle blunting in 73 (91.25%), and calcifications in 59 (73.75%) were seen on chest X-rays. With exposure, PFT decreased: FVC/FEV1 reduced from 3.90/3.33 L (<1 year) to 2.42/2.08 L (10 years), with 73.38.	Silicosis is an occupational respiratory disorder
K TILWANI 2014	Bikaner, a city in Rajasthan, India	cross-sectional study.	50 pregnant ladies in polluted environments. Control Group: 50 low-pollution pregnant women. Physical/mental fit, 20–35, uncomplicated pregnancy. High BP, asthma, TB, CVD, eclampsia, smoking, thoracic deformity, relevant medicines will be excluded.	High-traffic pollution was the predominant outdoor exposure. Polluted locations had more vehicle-emitted sulfur dioxide and ultrafine particles, although the article did not specify pollutant amounts. Duration: Exposure occurred throughout pregnancy. Completed 1st, 2nd, and 3rd trimesters (≤12, 12-24, 25-40 weeks).	In high-pollution locations, pregnant women had significantly decreased lung function throughout trimesters. Second and third trimesters had reduced FVC (1.98 ± 0.04 L vs. 2.175 ± 0.17 L, p=0.0001). Obstructive CRD was indicated by a significant decrease in FEV1 by the 3rd trimester (1.39 ± 0.037 L vs. 1.65 ± 0.13 L, p=0.0001). FEF25-75% and PEFR considerably decreased (e.g., 3rd trimester PEFR: 4.85 ± 0.13 L/s vs. higher values). As pregnancy progressed, FEV1/FVC dropped, indicating airway obstruction.	The study found that less polluted locations had substantially higher mean ± SD values of FVC, FEV1, and FEF25-75% throughout the second and third trimesters (p < 0.0001), but not in the first trimester. In all trimesters, FEV1/FVC and PEFR were consistently higher (p < 0.0001). Significant correlations revealed reduced lung function in polluted locations.	Obstructuve respiratory diseaes
Chopra 2012	Kamla Nehru Chest Hospital attached with Dr. SNMC Jodhpur, Rajasthan, India. The workers were from sand stone mines in areas like Soorsagar, Kaliberi, Keru, and Balesar near Jodhpur.	retrospective cohort study nos	Clinico-radiological silico-tuberculosis in 300 Jodhpur sandstone miners. Cutter/Driller (blasting/cutting), Dresser (chisel work), Labourer (loading/unloading).	Occupational exposure to silica dust Duration of exposure to silica particles: Ranged from 0-20 years (and beyond, though cases decrease after 20 years due to mortality). Work category: Cutter/driller, dresser, or labourer. Smoking status: 95% of stone workers were smokers. Addictions: 25% were addicted to opium, and 15% to alcohol.	Silica exposure raised silicotuberculosis risk over 20 years, then reduced due to lower survival. Among 300 patients, 137 (45.7%) were AFB smear-positive and 123 (41%) culture-confirmed; 66 (53.65%) had *M. tuberculosis* and 57 (46.34%) atypical mycobacteria. Everyday observations were cavities (41.6%), pleural involvement (33.9%), cough (80%), dyspnea (70%), and smoking (95%).	137 of 300 patients had Acid Fast Bacilli smear positive and 123 culture positive. With 66 (53.65%) typical Mycobacteria and 57 (46.34%) atypical, M. kansasii (28), M. scrofulaceum (9), M. ulcerans (1), and M. fortuitum (19) were found Atypical instances had additional imaging abnormalities such cavity with nodulation, pleural response, fibrosis, lower lobe involvement, and pneumothorax. Siliconotics had more pulmonary tuberculosis than others.	silico-tuberculosis , and diagnosed silicosis and tuberculosis

AUTHOR NAME YEAR	STUDY LOCATION	STUDY DESIGN	STUDY POPULATION	EXPOSURE	OUTCOME	RESULT	CRD OUTCOME
Alagarajan, 2022	Karauli district of Rajasthan, India	cross-sectional study.	Mining workers 218, ex-miners 137, non-miners 203. Defined as ≥3-year exposure or no mining experience. House-to-house, multistage, 10 villages' sampling.	Occupation/Work History: Current mine worker, Ex-mine worker, Non-mine worker (the primary exposure variable). Duration of Mining Exposure: current miners have at least 3 years.	Current and former miners had greater respiratory symptoms and lung damage than controls. Long-term cough was noted by 66.5% of current and 74.5% of ex-mine workers, compared to 21.7% of controls (p<0.001). Shortness of breath was 54% and 74%, wheezing 31% and 53%, compared to 8% (Adjusted odds ratios: ex-mine compared. controls—cough AOR=5.89 (95% CI:3.26–10.65), dyspnea AOR=9.51 (4.96–18.23); ex-mine vs. current—wheezing AOR=3.04 (1.74–5.32), hemoptysis AOR=2.28 (1. 90% of my employees and their households died from respiratory illness.	Ex-miners and present miners have more respiratory symptoms, injuries, eye and hearing issues, and dental health issues than non-miners. With higher self-reported morbidity, ex-miners were more likely to cough with blood, shortness of breath, and wheezing than present miners.	TB, an occupational lung disorder
Rahul 2016	Petrol pumps are in Jaipur city, Rajasthan, India.	Cross-sectional study.	Study Group: 40 men, 20-40 years old, non-smokers, non-drinkers, fuel attendants (≥8 h/day), mean exposure 9.78 ± 3.29 years. Control Group: 40 age- and sex-matched, non-smoking, non-alcoholic male ward boys/peons, 20–40 years, unexposed to petroleum fumes.	Exposure Type: Occupational exposure to gasoline fumes (air pollution source). Duration of Exposure: Mean 9.78 ± 3.29 years.	Petrol pumps increase the risk of restrictive pulmonary disease. Workers had 47.5% restricted, 10% obstructive, and 42.5% typical patterns. Comparative pulmonary function decline: FVC: 3.43 ± 0.35 FEV1: 2.84 ± 0.39 FEV1/FVC: 82.55 ± 5.65% vs. 84.46 ± 3.00%, p = 0.06 FEF25-75%: 2.95 ± 0.92L/s vs. 3.47 ± 0.56	Petrol pump workers showed substantial decreases in FVC, FEV1, FEF25-75%, and PEFR compared to controls (p<0.05), while FEV1/FVC (%) did not change significantly. The research found a significant correlation between occupational gasoline exposure and reduced lung function, with a mean duration of 9.78 ± 3.29 years.	Restrictive respiratory diseases
Mishra 2023	This study was conducted in the rural region of Jaipur, Rajasthan	cross-sectional study.	Participants: 121 random stone carvers from 19 units. A group of 83 stone carvers cut, finish, and polish. Control Group: 38 admins. For adults ≥18, ≥1-year exposure; excludes <18, spirometry contraindications.	Occupational Exposure: Stone carvers experienced dust pollution. Duration: 78% 1-5 years, >20% >10 years. Protection Masks: 45.7% exposed, 60.5% controls. • Smoking: 37.3% exposed, 31.5% controls had increased airway exposure.	Stone carvers exposed to heavy dust in which 78% worked 1-5 years (51.8% exposed; 42.1% controls) and over 20% over 10 years. Compared to exposed workers, exposed workers smoked more and used masks less frequently (45.7% vs. 60.5%). Chronic cough (63.8% vs. 18.4%, p < 0.01), phlegm (57.8% vs. 15.7%, p < 0.01), and decreased FEV1 (2.72L vs. 3.20L, p < 0.01) and FVC (3.36L vs. 3.72L, p = 0.02) suggest airway obstructions and reduced lung capacity.	Among 121 stone carvers (83 exposed, 38 controls), those with >10 years' experience had greater cough, phlegm, and chest illness, whereas those with 6–10 years had more wheezing, dyspnea, and mucus. Mask-free users coughed and phlegmed more. Smokers had lower FEV_1 and FVC, which was linked to cough and chest problems.	mixed restrictive-obstructive respiratory disorder
Ahmad 2015	Sorya Village, Karauli district, Rajasthan, India	cross-sectional study.	A study was conducted in Sorya village, Karauli, over 10 days (20–30 May 2014) among 126 miners in a dusty, outdoor mining environment.	Working as a miner (stone quarrying and crushing) Substance abuse (80% of miners), smoking	Among 126 miners, 9.5% (12/126) suffered from TB and 8.7% (11/126) from silicosis. Chronic cough was 43.7% (55/126), chest pain was 47.6% (60/126), and severe shortness of breath was 17.5% (22/126). Malnourished miners had a considerably greater risk of silicosis/TB	Underweight miners (BMI <18.5 kg/m²) have a 38% malnutrition risk, significantly linked to age (p =0.047). Most miners were drug addicts. Cough, chest pain, shortness of breath, musculoskeletal diseases, TB,	Silicosis, t.b.

AUTHOR NAME YEAR	STUDY LOCATION	STUDY DESIGN	STUDY POPULATION	EXPOSURE	OUTCOME	RESULT	CRD OUTCOME
					(HR = 5.61; 95% CI 1.88–16.78; p = 0.002), but non-substance users had a non-significant decreased risk (HR = 0.58), p = 0.298.	silicosis, and sensory impairments are common respiratory diseases. Silicosis/TB is 5.61 (95% CI 1.87–16.78) times more likely in malnourished miners after 20 years.	
Sharma 2024	Jaipur, Rajasthan, India, encompasses both urban (Commercial, Residential, Industrial, Slum) and rural areas.	Prospective cohort study	Inclusion Criteria: Residents ≥18, Jaipur ≥6 months, willing. Sample size: 147 people from 45 families (9 per area: Commercial, Residential, Industrial, Slum, Rural). 180 (4 adults/household) expected.	20% houses burned biomass. 49% lacked chimneys/exhausts. 22% smoke, 13% secondhand. Disposal: 49% clean. Dust 75%, pets 71%.	Out of 147 individuals, 14 (9.5%) had CRD, including COPD 2% (3/147), asthma 4% (6/147), and TB. Women had reduced mean FVC (2.05L) and FEV_1 (1.77L) compared to males (2.53L, p = 0.001). No gender difference was seen in obstructive FEV_1/FVC ratios (p = 0.119). PEFR/FEF trends were higher in males and urbanites, although rural and female individuals had reduced lung function lacking significance.	Bronchial asthma was 4% and COPD 2%. Only 4 acute CRD episodes reported. Mean FVC and FEV1 were significantly lower in females (P < 0.001) and rural regions (P < 0.005).	COPD, Asthma, T.B.
Gupta 2006	Jaipur district, Rajasthan, India.	cross-sectional study.	Planning Sample: 15,000 subjects (~0.03% of Jaipur's population, 5,252,388, Census 2001). Responses: 12,805 (85.4%). Analyzed Population: 8,863 adults (minus 3,942 <15 years).	Smoking: 15.1% (1,336/8,863); males 1,332, females 52; cigarettes 9.7%, bidi 3.3%, hookah 1.4%. ETS: 46% (2,879) non-smokers exposed, mostly females via husbands. Cooking Fuel: 35.1% (3,110) frequent; rural coal 11.1%, dung 4.8%, wood 0.7%; urban LPG 16.4%. Survey: August 2002–February 2003; chronic, long-term exposures.	Urban participants (3.6%) reported less respiratory issues than rural (6.8%). Overall asthma prevalence was 0.96% (rural 1.86%, urban 1.44%, females 0.38%), with current asthma 0.5%. Cough (3.3%), dyspnea (2.8%), phlegm (2.4%), wheeze (2.0%), and chest tightness (1.6%) were common. Rural men and women had more wheezing and dyspnea. Atopy was 3.8%, family history 0.3%, and inhaler usage 0.8%, suggesting undertreatment.	Among 8,863 responders aged ≥15 years (5,010 men, 3,853 females), 5.3% reported respiratory diseases. Overall asthma prevalence was 0.96%: 1.86% rural men, 1.44% rural females, 0.51% urban males, 0.38% urban females. High risk factors included atopy, age, rural living, and tobacco use, especially hookah.	asthma
Joshi 2013	Rural areas of Jaipur district, Rajasthan, India.	Cross-sectional study.	Cooks (n=90): Rural primary cooks exposed to unprocessed solid biofuel indoor air pollution. Comparison group: rural non-cooks (n=94). Sample size: 184.	Indoor Air Pollution: Rural cooking with unprocessed solid biofuels, poor ventilation → high exposure. Exposure Categories: Kitchen-in-living-room, outdoor kitchen; study area lacks open kitchens.	Coughing 75.9% vs. 23.1% (p=0.00), wheezing, phlegm, and dyspnea were more common among cooks. Chronic exposure led to reduced lung function: FEV_1/FVC 82.19% ± 7.48 vs. 89.94% ± 8.26 (p=0.00), FVC% 76.58% ± 12.25 vs. 83.05% ± 15.84, showing early obstructive changes.	Cooks of all ages had decreased FEV1/FVC (p = 0.00). 25–40-year-old chefs had reduced FVC% Predicted (p=0.04). The mean FEV1% Predicted (Cooks: 86.82±7.31; non-cooks: 87.18±15.91) and FEV1/FVC were significantly different (p 0.001). Cooks had more wheeze, coughing, phlegm, and dyspnea at 25–40 years (p = 0.004).	Obstructive respiratory diseases
Singh 2009	Jaipur city, Rajasthan, India. Specifically, traffic areas for the exposed group and city outskirts for the control group.	Cross-sectional study.	Exposure: 350 Rajasthan Police officers controlling Jaipur traffic. Control Group: 164	Main exposure: Jaipur traffic workers, heavy pollution (RSPM 170.8 µg/m³). Control: Low pollution (RSPM 12.85 µg/m³) in non-traffic	Smokers' mean FEV_1 did not vary between traffic and non-traffic groups (95% CI: 0.782–9.667; p = 0.095). For non-smokers, traffic officers had a substantially higher FEV_1 (95.3 ± 13.6 vs.	Jaipur traffic officers exposed to traffic had significant respiratory impacts with reduced FEV1. FEV1 showed considerable variation among non-smokers, including	Obstructive respiratory diseases

AUTHOR NAME YEAR	STUDY LOCATION	STUDY DESIGN	STUDY POPULATION	EXPOSURE	OUTCOME	RESULT	CRD OUTCOME
			Rajasthan Arms Constabulary non-traffic policemen outside city boundaries.	outskirts Smoking History: Traffic: 3.26 ± 8.89, Non-traffic: 2.95 ± 7.98 pack-years	87.8 ± 0.95; 95% CI: 4.420–10.517; p =0.001 Traffic exposure duration did not dramatically affect FEV_1 (p = 0.215). People exposed to traffic had higher coughs and dyspnea.	smokers: 95.3 ± 13.6% vs 87.8 ± 0.95% (95% CI: 4.420–10.517, p = 0.001). Lung function tests reveal significant respiratory impairment in high-traffic groups compared to controls.	
Sharda, N, 2000	Chandpole area in Jaipur, Rajasthan, India.	Cross-sectional study.	A random sample of 200 marble sculptors with ≥2 years of experience was chosen. Control group: 42 non-sculptors, with a similar environment and socioeconomic background, non-smokers, and non-tobacco chewers.	Principal Exposure: Marble dust (sculptors) Additional Risks: Smokers, non-smokers, tobacco chewers vs non-chewers Exposure Duration: Symptomatic 17.75 ±11.67 years; Asymptomatic 15 ±10.55 years	Marble sculptors 45% had respiratory problems compared to 24% of controls (p<0.02). Sculptors had an average PEFR of 7.5 ± 1.45 L/s, whereas controls had 8.0 ± 1.5 L/s (p<0.05 Healthy PEFR 62% vs 83.3%; airflow blockage mild 29.5% vs 14.3%, moderate 8% vs 2.4%, severe 0.5% vs 0%. Marble dust, smoking, and tobacco influence symptoms, with smoking causing a substantial impact (p<0.001).	In Chandpole, Jaipur, 200 marble sculptors and 42 nonsmoking, nontobacco-using controls participated in a research to evaluate respiratory symptoms. Compared to 24% of controls, 45% of sculptors reported having a persistent cough, phlegm, dyspnea, or wheezing. Tobacco usage and marble dust exposure were linked to outliers, demonstrating the substantial negative effects of smoking and occupational dust on respiratory health.	Obstructuve respiratory diseaes
Tyagi 2013	Desert districts of Rajasthan, India, specifically stone mines in the vicinity of Jodhpur city. The visited mining areas included Mandor, Kaliberi, Sursagar, Keru, Balesar, Gagari, 11 Mil, Bhat Basti, Belclor Basti, and Ambedkarnagar.	cross-sectional study.	Sample: 221 mining workers (including disabled retirees). Self-selected, purposive; reacted to mine/residential health check-up offers.	Occupational Exposure: Stone mine work exposes to dust and hazards. Lifestyle Factors: Tobacco 80%, alcohol 52%. Past Medical History: Tuberculosis 25.33% overall, 45% in phase one.	Respiratory symptom was reported by 58.8%, including dyspnea (32.1%), cough (31.7%), and chest discomfort (24.4%). Clinical results included chronic respiratory infection (21.3%), silico-tuberculosis (11.3%), silicosis (14.9%), TB (17.2%), and significant function test restrictions.	Workers were 15–84 years old, with 28.6% under 30. Tobacco (80%) and alcohol (52%). In 25.33%, TB therapy was past. Complaints included dyspnea (32.1%), cough (31.7%), and chest discomfort (24.4%). Morbidities included chronic respiratory tract infection (21.3%), silico-tuberculosis (11.3%), digestive issues (24.4%), and joint disorders (23.3%).	chronic respiratory tract infection ,, silico-tuberculosis , and diagnosed silicosis and tuberculosis
Kumari 2016	Kamla Nehru Chest Hospital, Jodhpur, Western Rajasthan, India.	cross-sectional study.	Patient population: 104 chronic simple silicosis patients Based on work history and ILO pneumoconiosis radiographs. Age >18, no co-morbidities	Occupational Exposure to Silica: Specifically, categorized by occupation into "drillers" and "dressers." Duration of Silica Exposure (DSE): Mean DSE of 21.3 ± 8.6 years. Smoking Pack Years (SPY): Categorized into groups: nil, 1-10, 11-20, and >20 SPY.	There were 62.5% spirometric abnormalities (53.3% non-smokers; 1–10 SPY: 60%, 11–20 SPY: 55.2%, >20 SPY: 84% For ≥20 SPY, restrictive/mixed patterns prevailed. Compared to 42.85%, drillers had greater mixed patterns, FVC, and oxygen desaturation (63.4%). Patients with abnormal spirometry (69.3%) and post-6MWT desaturation (>4% or <90%) had higher MPAP (>20 mmHg) and decreased FEV1 with SPY	62.5% (65/104) had abnormal spirometry, post-6MWT OD, and TTE, greatest in >20 SPY (84%; 81/25) and drillers (68.3%; 28/41). Post-6MWT OD occurred in 50.96% (53/104), >20 SPY (56%; 14/25), and drillers (63.4%; 26/41). Obstructive/mixed patterns predominated >20 SPY, restricted <20 SPY; drillers varied. Spirometry is associated to pulmonary hypertension (69.3%; 45/65) and OD (79.3%; 42/53).	obstructive respiratory diseaes , restrictive respiratory diseases , mixed respiratory pattern
Rajavel 2020	Sandstone mines in Jodhpur, Rajasthan,	cross-sectional study.	174 mine workers exposed to silica dust in	Sandstone mining-related silica dust exposure.	Silico-TB was 7.4%, tuberculosis 10%, and silicosis 37.3%, with emphysema/pleural	Average age of mine workers was 39.13 ± 11.09 years. There were	progressive massive fibrosis.

AUTHOR NAME YEAR	STUDY LOCATION	STUDY DESIGN	STUDY POPULATION	EXPOSURE	OUTCOME	RESULT	CRD OUTCOME
	India. Specifically, 15 mines were selected out of 45 sandstone mines.		sandstone mines in Jodhpur. Those available and willing to participate were recruited until the sample size was achieved.	Duration of mining work: 18.88 ± 9.81 years (range 1.5-50 years). 75.3% worked 10+ years. Work hours: Average 7.09 ± 1.42 hours per day (2-12 hours range). About 96% worked ≥ 8 hours daily.	effusion 4.3%. An abnormal 89.2% spirometry. Among 145 workers, 89.7% had restricted lung function (78%, 11.7% mixed, 10.3% normal). Reticulo-nodular opacity was 81%, progressive extensive fibrosis 20%, and sputum smear positive 61.8% in 67.7% and 22% of men and females.	75.3% >10 years of mining experience, 30.0% TB, 89.2% abnormal spirometry, and 42.0% abnormal chest radiography. Sandstone miners had substantial respiratory morbidity, including silicosis (37.3%), silico-TB (7.4%), tuberculosis (10.0%), and emphysema/pleural effusion (4.3%).	Silicosis , T.B., emphysema, pleural effusion silico-tuberculosis,
Nandi 2021	Karauli and Dholpur districts, Rajasthan, India (specifically focusing on sandstone mine workers in these areas).	cross-sectional study.	Initially, 572 people were examined. Poor chest radiography excluded 43 people. The final study population included 529 stone mine workers with respiratory illness and NGO-suspected chronic pulmonary TB	Duration of work in stone mines: Categorized as <=10 years, 11-20 years, 21-30 years, and >30 years. Exposure to high levels of airborne silica (implied by their occupation in stone mines).	Silicosis was 52% (275/529), PMF 7.5% (40/529), silicotuberculosis 12.4% (66/529), and TB radiography 9.4% (50/529). Silicosis and PMF prevalence substantially increase with work time (p<0.001). DOTS completion was 85.6% (453/529).	Silicosis was seen in 275 (52%) of 529 chest X-rays. Of those involved, 40 (7.5%) had large opacities indicating increasing severe fibrosis. Silicosis and progressive extensive fibrosis were linked with longer hours of work in stone mines. In 61 cases (12.4%), silicosis was silico-tuberculosis.	Silicosis T.B. Progressive Massive Fibrosis Silico-tuberculosis
Gupta 1999	Jodhpur town, Rajasthan, India.	Cross-sectional study.	92 male quarry workers. Out of which 76 were involved in cutting the stone and formed group I and 16 doing the job of loading/ unloading the stone constituted group II.	Exposure Source: Stone quarry work. Groups: I – stone-cutting/direct dust; II – loading/unloading/less acute dust. Work Duration: I: 9.32±6.03 yrs; II: 18.44±7.04 yrs. Smoking History: Smokers/non-smokers.	Coughing with sputum (55%), chest pain (79%), bodyache (31%), and TB history (21%). With lung function below Rajasthan limits, Group II workers had considerably lower FEV and PEFR than Group I. There was no smoker–nonsmoker variance, indicating that stone dust exposure is the main cause of pulmonary function loss.	Patients reported cough with sputum (55%), chest pain (79%), bodyache (31%), and TB history (21%). Group II had lower FEV and PEFR than I. Lung function was lower than Rajasthan levels, regardless of smoking status, suggesting stone dust exposure.	occupational respiratory diseases
Kohli 2020	Sirohi, Rajasthan, India. Specifically, Occupational Disease Centre Basaidarapur.	Cross-sectional study.	45 symptomatic stone carvers from Sirohi who fulfilled the criteria of silica exposure, had already undergone preliminary screening, and were referred to the Occupational Disease Centre for evaluation for compensation.	Silica Exposure: All stone carvers met silica exposure criteria. Duration: Exposure 8–22 years; 55% silicosis cases worked 15–20 years.	HRCT revealed parenchymal lesions more than X-ray, and 44.4% (n=20) had calcified hilar lymph nodes, 33.3% (n=15) nodules, 26.6% (n=12) emphysema, 48.9% (n=22) mediastinal lymphatic nodules, 53.3% (n=24) pleural thickening, and 6.6% (n=3) silicotuberculosis.	In 45 male stone carvers (mean age 40, exposure 8–22 years), 53% exhibited circular opacities, 24.4% irregular, 48.9% profusion-1/1, 22.2% big, 44.4% calcified hilar nodes, 26.6% emphysema, 48.9% mediastinal nodules, 53.3% pleural thickening, and 6.6% silico-tuberculosis	silicosis , Silico-tuberculosis , emphysema, pleural thickening, pulmonary fibrosis

Radiologic Findings, Symptom Exacerbations, and Pulmonary Dysfunction

Research conducted throughout Rajasthan has indicated that lung function varies with occupational, outdoor, and indoor pollution. Among 80 stone miners in Jaipur, 60% had restrictive FVC (2.41 ± 0.54 L; FEV_1 2.02 L), 22.5% mixed, 5% obstructive, and 12.5% normal The study revealed a major decrease in FEV_1 (2.20 ± 0.32 L; p = 0.024) and FVC (3.33–3.90 L; p ≤ 0.008) in silicosis (87.6 ± 8.94%(25). Bikaner women in their third trimester living in high-polluted areas had lower PEFR, FEV_1, and FVC (4.85 ± 0.13 vs 5.25 ± 0.09 L/s; 1.39 ± 0.037 vs 1.65 ± 0.13 L; 1.98 ± 0.04 vs 2.175 ± 0.17 L)(16). Quarry workers in Jodhpur had lower FEV_1 (p=0.02) and PEFR (p=0.00) than cutters, which were linked to age and experience.(10) Silicosis patients at Kamla Nehru Chest Hospital reported abnormal spirometry in 60% (1–10 SPY), 55.2% (11–20 SPY), and 84% (>20 SPY). Obstructive/restrictive patterns plagued dressers and 68.3% mixed faults in drills. After 6MWT, 50.96% desaturation (drillers 63.4%, >20 SPY 56%) and decreased FEV_1/FVC in >20 SPY(18).

In Jaipur marble sculptors, PEFR was 7.5 ± 1.45 vs. 8.0 ± 1.5 L/s (p<0.05), with 29.5% vs. 14.3% obstruction, 8% vs. 2.4% moderate obstruction, and 0.5% vs. 0% severe obstruction(11).

Miners in rural Jaipur had a lot of coughs (63.8%), phlegm (57.8%), and chest infections (48.2%), and their lung volumes were lower: FEV_1 2.72 L and FVC 3.36 L.(24). Petrol pump employees (9.8 ± 3.3 years) exhibited decreased FVC, FEV_1, PEFR, and $FEF_{25–75}$% (p<0.01), with 47.5% revealing restrictive patterns and 10% exhibiting obstructive patterns. Exposure to biomass reduced FEV_1%, FEV_1/FVC, and elevated cough incidence (75.9% vs. 23.1%; p=0.001).(19).Cooks that worked with biomass had worse FEV_1% and FEV_1/FVC and a lot more coughs (75.9% vs. 23.1%; p=0.00) (15).

i) Obstructive respiratory disorder *(Asthma)*

In cross-sectional study conducted in Jaipur, 5.3% of 8,863 individuals had obstructive respiratory disease, with a higher incidence in rural areas (6.8%) compared to urban areas (3.6%). Cough (3.3%), dyspnea (2.8%), phlegm (2.4%), and wheezing (2.0%) are common symptoms. Asthma 0.96%, mostly in rural males; atopy 3.8%(12).

B. Prospective Study

i) Obstructive respiratory disorder *(COPD & Asthma)*

Among the 147 Jaipur residents studied, 4% had asthma and 2% had COPD, with men showing higher mean FVC than women (2.53 L vs 2.05 L; p=0.001), and rural dwellers had a lower mean FVC (p The mean FEV_1 for men and women was 2.34 L and 1.77 L, respectively (p<0.001), with no sex difference in FEV/FVC (p=0.119). We found no significant differences in the FEF or PEFR(26).

ii) Restrictive respiratory disorder Silicosis

Among 300 sandstone miners from Jodhpur, 53.7% had typical mycobacterial lung illnesses, mostly M. kansasii (28 cases) and M. fortuitum (19 cases). Smear: 45.7%, culture: 41%. Radiographs revealed cavitary 41.6%) and pleural 33.9%). Coughing 80%, shortness of breath 70%, and coughing up blood 43%; 95% smoked, and 25% took opium(27).

OCCUPATIONAL EXPOSURE – RESPIRABLE CRYSTALLINE SILICA DUST

Respirable crystalline silica dust is a significant hazard in stone mining and carving. Of the 80 male workers, 76.25% had been exceeding 10 years, while 6.25% had exposed for 5 years or less. The average age was 44.39 years, indicating prolonged exposure in the middle-aged population at risk for respiratory diseases(25). An analysis of 300 mine workers with silico-tuberculosis found 95% smoked. Dust handling increases dust exposure in cutters and drillers. Disease progression has resulted in increased survival rates after 20 years(27). Long-term occupational dust exposure caused TB in 49.6% of ex-mine workers and 3% of non-mine workers. Current employees have been exposed for 3 years(23). Despite exposure for ≥1 year and >20% for over 10 years, only 45.7% of stone carvers wore masks(24). Although the duration was unknown, quarry workers were chronically exposed, and 80% used tobacco(17).Stone miners had 80% tobacco use, 52% alcohol use, and 25.33% TB history, indicating occupational and lifestyle factors(14). Workers in drilling/dressing had 21.3 ± 8.6 years of exposure and varied smoking histories(18). A low-educated workforce had 75.3% silica exposure over 10 years, working 7.09 ± 1.42 hours daily, with men in high-risk roles(21). Additional research has confirmed cumulative exposure ranging from ≤10 to >30 years (22)(10), while loaders had an average exposure of 9.32 ± 6.03 years, while loaders had 18.44 ± 7.04 years, the former being more intense. Eight–22 years of exposure in artisanal stone carvings, with 55% working 15–20 years, suggests long-term respiratory risks(20).

AMBIENT AIR POLLUTION

Vehicular Emissions and VOCs

In Jaipur, traffic police were exposed to 170.8 μg/m³ RSPM, while non-traffic areas had 12.85 μg/m³. Smoking exacerbates occupational exposure(13). Petrol pump workers were exposed to VOCs from gasoline vapours for 9.78 ± 3.29 years, resulting in uninterrupted outdoor air pollution(19). Pregnant women in Bikaner experience traffic-related outdoor air pollution. Exposure to traffic raises sulfur dioxide and particulate matter exposure(16).

Marble dust

Marble sculptors showed mean exposures of 17.75 ± 11.67 years (symptomatic) and 15 ± 10.55 years (asymptomatic), with a strong dose-response relationship(11).

Indoor Air Pollution – Solid Fuels, ETS, And Hygiene Factors

Indoor air pollution significantly affected household exposure. ETS exposure was reported in 46% of 8,863 non-smokers, mostly women. Coal (11.1%), dung (4.8%), and wood (0.7%) were used by rural households(12). Inadequate ventilation and a lack of partitions increase cooking exposure(15). Another study found 20% of households used biomass fuel, 49% lacked ventilation, and 35% lived with tobacco smoke (22% active, 13% passive). Visible dust (75%) and animal presence (71%) increased household pollution health risks(26).

DISCUSSION

To the best of our knowledge, this is the first broad review of this topic; hence, the manuscript is organized into two domains: (1) occupational dust-related CRDs, including silicosis and silico-tuberculosis, and (2) ambient air pollution-related CRDs, including traffic and household pollution exposures.

From 1999 to 2024, we selected 18 articles that fulfilled our selection criteria, with the majority of studies conducted in the Aravalli Range, Jaipur District(25,24,26,12,15,13,11,19), Sirohi District Eastern Semi-arid Plain(20), and Jodhpur District(27,14,18,21,10). Eastern Plain Dholpur (22) and Karauli Districts(23). The Sandy Arid Western Bikaner District was covered(16). The Hadoti Plateau has not been covered by any research.

Similar to other assessments, CRD is a significant factor for morbidity and mortality in India.

both indoor and outdoor air pollution have an impact on respiratory health (28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,65).This review included 18 studies: 16 cross-sectional,(10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25) 1 prospective(26), and 1 retrospective(27). Due to a lack of cohort and case-control comparison research, we could not analyze exposure-disease associations of long-term air pollution respiratory effects. This contrasts with the findings of prior Indian and global studies. Some Indian studies have employed case-control cohort methods to explore the adverse respiratory effects of air pollution(46,47,48,49,50,51,52,53,54). Using cohort studies, international researchers have examined the long-term respiratory consequences associated with air pollution and its health impacts(55,56,57,58,59,60).

In this research, Tuberculosis was considered both as a secondary outcome in individuals with silicosis and as an independent outcome in non-silicosis populations, thus identifying the incidence of TB, silicotuberculosis, and progressive massive fibrosis, as well as respiratory patterns, indicating 60% restrictive, 5-7% obstructive, 22% mixed, and 12% normal. This finding has been further strengthened by several significant international studies on the increasing prevalence of chronic respiratory disorders(61,62,63,64).

However, in selected reviews, disease coverage gaps were noted, such as emphysema, cancer of the lung and intrathoracic organs, pulmonary eosinophilia, chronic pleural diseases, lung fibrosis, lung failure, and pulmonary hypertension. These conditions have been studied in relation to air pollution in India and globally. ILD have been studied(65,66,28,67,68,69,70) in (34,71,72,73,74,75,76,77,78,79) plueral and pulmonary fibrosis and pulmonary hypertension studies (80,81,82,28,83,84,85,86,87).

This review (15,26,12)highlighted significant indoor exposure factors, including biomass fuels, inadequate ventilation, visible dust, and animal droppings. A significant finding was prolonged exposure to wood, dung, and crop smoke, which was associated with a 9.5% risk of chronic respiratory diseases and 22% smoking rate. Cooks exposed to biofuel smoke showed an increased cough and reduced FEV_1/FVC and FVC%, indicating obstructive patterns and wheezing. These results correlate with those of similar research conducted in India and other countries (88,89,90,91,92,93,94,95,96,97). However, studies on indoor air pollution and CRDs are scarce. This contrasts with other Indian and global studies that extensively document the health impacts of household air pollution from biomass fuels(98,99). Studies in rural India(97,93) and countries such as Nepal(100,101,102) and Sub-Saharan Africa (103,104) have provided detailed analyses of respiratory morbidity associated with cooking emissions and poor indoor air quality, often including monitoring of pollutants and assessment of health outcomes(96). Studies conducted in Rajasthan concerning ambient pollutants from traffic and petrol pumps(11,16,13,19) revealed significant respiratory effects; however, they lacked reliable CRD diagnosis and radiographic data. Studies conducted in the city of Delhi revealed respiratory health problems caused by vehicular exhaust among traffic police personnel(105,106,107,108). Research has shown an association between traffic-related air pollution and various chronic respiratory diseases (CRDs) such as COPD and asthma. Studies conducted in Beijing and various cities in the US have examined the effects of roadside exposure on respiratory health(109,110). However, many studies lack an innovative diagnostic approach and radiographic test for accurate result analysis and real-time monitoring of pollutants.

CONCLUSION

This systematic review confirms a significant CRD burden in Rajasthan associated with occupational silica exposure, ambient vehicular emissions, petroleum exposure, and household biomass combustion. Silicosis (8%–52%), silico-tuberculosis (7%–12%), tuberculosis (9%–17%), and widespread restrictive spirometric impairment demonstrate preventable respiratory morbidity. Evidence gaps remain due to limited longitudinal research, inadequate exposure monitoring, insufficient confounder adjustment, and limited geographic coverage, particularly in the Hadoti Plateau. Future research should prioritise prospective designs, standardised spirometry and HRCT protocols, and inclusion of neglected demographic groups. A meta-analysis wasn't feasible due to substantial diversity in study designs and outcome measures.

RECOMMENDATION

Recommendations (Public Health Importance)

1. Implement mandatory periodic health screening of mining and quarry workers using spirometry and chest imaging for early detection of CRDs.
2. Ensure strict enforcement of respiratory protective equipment use and dust suppression measures in mining and stone-processing units.
3. Expand ambient air quality monitoring systems in under-studied districts, particularly the Hadoti Plateau region.
4. Strengthen clean cooking fuel programmes to reduce biomass fuel dependence in rural households.
5. Integrate chronic respiratory disease (CRD) screening services into Primary Health

Centres under the NP-NCD programme, with targeted outreach for high-risk occupational groups.

6. Promote and fund prospective cohort studies incorporating real-time exposure assessment and multivariable statistical analysis to improve causal inference.

Limitation of the Study

This review included only English-language studies, and some full texts were unavailable. Most studies were cross-sectional, limiting causal inference. No study reported multivariable regression or standardised effect estimates. Heterogeneity in exposure and outcomes prevented meta-analysis. Geographic coverage was incomplete, particularly for the Hadoti Plateau. Paediatric, geriatric, and tribal populations were not represented. Studies from 1999–2025 were difficult to compare due to changing pollution levels and diagnostic criteria. Future research should ensure uniform reporting of effect sizes (OR/RR, 95% CI) and standardised exposure-outcome measures.

Relevance of the Study

This review presents the first systematic synthesis of air pollution–related CRD burden in Rajasthan. It summarises prevalence estimates of silicosis, silico-tuberculosis, and TB, and identifies key high-risk groups including miners, traffic police, petrol pump workers, biomass fuel cooks, and pregnant women. It also highlights the complete lack of evidence from the Hadoti Plateau and notes major methodological gaps, such as limited HRCT use and absence of confounder-adjusted analysis. Findings support occupational health policy strengthening, NCAP planning, and clean fuel interventions.

Authors Contribution

All authors have contributed equally.

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Nil

Conflict of Interest

There are no conflicts of interest.

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Declaration Of Generative Ai And Ai Assisted Technologies In The Writing Process

During manuscript preparation, Grammarly was used for language editing, Mendeley for reference management, and Rayyan/Covidence for screening. PubMed & other supported literature retrieval. Authors reviewed all outputs and take full responsibility.

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