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Association Between Respiratory Symptoms and Indoor Air Quality in Small Workshops in Babil City in Iraq

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Abstract

Background: Poor indoor air quality in occupational settings is a significant public health issue as the small workshop's workers are continuously exposed to airborne pollutants. Aim: This study was aimed to identify the relationship between the indoor air and respiratory symptomatic that affect workers in small workshops in Babylon City-Iraq.

Methods: Cross-sectional analytical study conducted from September 2025 till March 2026 among the workers of 40 small workshops in Babylon City, Iraq. The detectors of various physical and chemical factors impulses are the portable calibrated instruments that were used to assess indoor air quality, measuring particulate matter ($PM_{2.5}$, and PM_{10}). Respiratory symptoms such as persistent cough, sputum production, wheezing, dyspnea, chest tightness, nasal and throat irritation were evaluated using a semi-structured questionnaire adapted from the American Thoracic Society (ATS). **Results**: Overall, 63.0% of workers had at least one respiratory symptom: Persistent cough (41.0%), and nasal irritation (38.0%) were the most commonly reported complaints. Higher levels of PM_2. Relationship between respiratory symptoms and concentrations of particulate matter, PM_{25} ($\chi^2 = 24.86$, $P < 0.001$), PM_{10} ($\chi^2 = 18.79$, $P < 0.001$), CO_2 ($\chi^2 = 6.47$, $P = 0.011$) and VOCs ($\chi^2 = 7.95$, $P = 0.005$). Respiratory symptoms related to exposure to carbon monoxide were not statistically significant ($P = 0.576$). **Conclusion**: The poor indoor air quality was strongly related to the presence of respiratory symptoms among workers in small workshops located in Babylon City. Higher levels of particulate matter, carbon dioxide, and volatile organic compounds are key occupational health risks.

Keywords: Indoor Air Quality, VOCs, Respiratory Symptoms, Airborne Pollutants

Introduction

Indoor air quality (IAQ) is an increasingly important public health issue, especially among workers who are confined to buildings with limited ventilation for long hours. Indoor air quality is defined by the concentrations of different pollutants like Particulate matter (PM), Volatile organic compounds (VOCs), Carbon monoxide, NOx and biological contaminants, which adversely affect human health (Tanir & Mete, 2022). Small-scale workshops, where industrial operations like welding, painting and vehicle repair are performed as well as being a usual place for workers to be exposed to certain hazardous airborne agents such as dust, exhaust fumes, fuel vapors and solvent emissions (Alahmari et al., 2020).

These exposures have been steadily shown to result in harmful respiratory outcomes, including acute symptoms such as cough and chest tightness to chronic outcomes such as chronic obstructive pulmonary disease (COPD) and lowest lung function (Jo, 2022). Since these are occupational exposures, knowing if indoor air pollutants relate to respiratory symptoms among workshop workers can help in planning future public health intervention. Small workshops is a specific type of working environment with particularly high risks, especially in developing countries where any regulatory framework aimed at ensuring workplace safety are often lacking or poorly enforced (Ahmad & Balkhyour, 2020). Workers operating in these environments are often working without personal protective equipment (PPE) and within poorly ventilated spaces with the potential to accumulate harmful environmental pollutants (Tanir & Mete, 2022).

In a study among small-scale industry workers in Saudi Arabia, reported respiratory symptoms were mainly chest tightness or wheezing (85% of exposed workers); nearly all pulmonary function parameters were significantly lower than non-exposed controls (Alahmari et al., 2020). Moreover, previous studies highlighted that only a few workers used airway protection as face masks, which reflects extremely low levels of occupational hygiene and suggests an outright need for both surveillance and preventive measures in these work environments (Farah et al., 2026). In the same vein, studies on indoor air pollution in developing countries have shown that household exposure to smoke from biomass and other products of combustion in poorly ventilated environments contributes substantially to the burden of respiratory disease, including acute respiratory infections and chronic bronchitis (Bruce et al., 2000).

Particulate matter (PM) includes a set of finely divided solid particles and fluid deposits suspended in the air. Such subdivisions are categorized by aerodynamic diameter and vary in size, geometry and source. Among them, PM_2. Particularly worrying is PM (2.5) — particles with diameters of 2.5 µm or smaller which can penetrate far into the respiratory system, and even enter the bloodstream. PM_{10} is defined as particulate matter advantages with diameter ≤10 µm (Ayano et al., 2026). The World Health Organization has considered PM as the riskiest environmental pollutant for respiratory and cardiovascular illness and death (World Health Organization, 2021). During occupational exposures, the levels of fine particles that can come from methods like welding and fuel combustion were 100 times larger than the recommended standards which can lead to acute and chronic conditions (Badima et al., 2024). Studies in work environments have demonstrated that even at low concentrations indoor particulate matter can induce symptoms of sick building syndrome (SBS), such as nasal congestion, throat irritation and fatigue which may progress to more severe building-related illnesses given enough exposure (Tepeneu et al., 2024).

The Middle East (ME) region, including Iraq, is particularly vulnerable to rapid urbanization induced air pollution changes along with industrial development and environmental degradation which are among the factors contributing significantly to impairing indoor climate conditions (Irankunda et al., 2025). In cities like Babylon in Iraq, countless small workshops operate with little environmental control exposing workers to a unique blend of chemical mix that enters the air (Issa et al., 2029). Occupational air pollution is increasingly recognized as a public health priority, but empirical research exploring its link with respiratory symptoms among small workshop workers in Iraqi cities remains sparse. Prior studies in neighboring countries and similar settings have shown a high burden of respiratory disease among workers exposed to indoor air pollutants but the context-specific factors influencing exposure and health outcomes in Iraqi workshops remain poorly characterized (Abbas & Mohammed., 2026). Particularly filling this gap in the literature is necessary to develop evidence-based policies and interventions that can safeguard the health of a neglected occupational group.

Hence, the study aimed to determine the relationship between indoor air quality and respiratory symptoms among workers of small workshops in Babylon City, Iraq. Through evaluation of sensory respiratory symptoms along with objective methods to measure the levels of indoor air pollutants, this study aims to define occupational health risks for workshop workers in this field setting. The results will add to the existing literature on indoor air pollution in developing countries and provide information directed towards public health policy and interventions aimed at reducing occupational respiratory disease in similar settings.

Methods

Study Design and Setting

Designing a cross-sectional community-based study of respiratory symptoms and indoor air quality factors among workers in Babylon City, Iraq. The study occurred from September 2025 to March 2026 over a course of seven months. The workshops examined included; welding, automobile repair, carpentry, metal fabrication, painting and samples from the electrical maintenance and mechanical service industry sectors.

Study Population

Study population The study sample included workers hired in (40) small workshops distributed over 2 main sites at different districts of Babylon City. Workers eligible to participate were those who were 18 years or older, continuously working in their current workshop for at least one year and had been directly involved with workshop activities related to exposure respiratory airborne pollutants (n=200). To minimize potential confounding the workers who had previously been diagnosed with chronic respiratory diseases that were not related to occupational exposure (e.g., pulmonary fibrosis, bronchiectasis, lung cancer or congenital respiratory disorders) were excluded from analyses.

Sample Size and Sampling Technique

The current study utilized a purposive sampling method to recruit individuals in the selected workshops. Minimum sample size was determined using Cochran's formula for cross-sectional surveys considering 50% prevalence of respiratory symptoms among workers, confidence level: 95%, and margin of error = 5%. In advance of data collection, workshop owners were approached and permission was granted to perform environmental monitoring and worker interviews. Workers who met the inclusion criteria and agreed to participate were enrolled after giving informed consent (n=200).

Data Collection Tools and Procedures

Data were composed of three aspects: (Demographic and occupational characteristics, evaluation of respiratory symptoms and indoor air quality measurements.

Assessment of Respiratory Symptoms

Respiratory symptoms were assessed using a standardized questionnaire modeled after the American Thoracic Society (ATS) respiratory symptom questionnaire. Each of the participants was inquired if they had any of the following symptoms during last three months:

Persistent cough

Sputum production

Wheezing

Shortness of breath (dyspnea)

Chest tightness

Nasal irritation

Throat irritation

Each symptom was recorded as yes or no.

Indoor Air Quality Assessment

The indoor air quality within each workshop was monitored in situ using portable, calibrated environmental monitoring instruments. Because data were collected in tandem with standard routine occupational activities, measurements occurred during the normal hours of work (9:00 AM–1:00 PM) to reflect real-world exposure conditions.

The following environmental parameters were measured:

Particulate Matter ($PM_{2.5}$) (µg/m³)

Particulate Matter (PM_{10}) (µg/m³)

Carbon Monoxide (CO) (ppm)

Carbon Dioxide (CO_2) (ppm)

Volatile Organic Compounds (VOCs) (ppm)

Temperature (°C)

Relative Humidity (%)

Measurements were taken at around 1.5 m, relative to floor level in the central working area of each of the workshops. The final value for the three consecutive readings collected at intervals of 15 min each was averaged and used for statistical analysis. Air quality instruments were calibrated as per manufacturers guidelines prior to each field visit.

Validity and Reliability

Establishing content validity, the questionnaire was then reviewed by a panel of experts in occupational medicine, environmental health, respiratory medicine and epidemiology. The final Content Validity Index (CVI) was 0.91 which showed very good content validity. Cronbach's alpha coefficient was calculated to evaluate the internal consistency reliability of the respiratory symptom questionnaire and was 0.88, indicating good reliability.

Ethical Considerations

Ethical approval was obtained from the Scientific Research Ethics Committee of the respective academic institution prior to study commencement. Local authorities and workshop owners also provided formal approval. All the participants were informed about the objectives, procedures and benefits of the study their written consent was obtained before enrolment even to take part in the study would not affect future medical care. The study was performed under the condition of confidentiality and anonymity of collected data, and all participants were informed from the beginning about their right to refuse participation at any time during the investigation without providing a reason.

Statistical Analysis

Data entry and analysis was performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD) after testing for normality using the Shapiro–Wilk test, and categorical variables were described by frequencies and percentages. The Chi-square test or Fisher's exact test, as appropriate, was used to assess the association between each respiratory symptom and each of the categorical variables. Pearson or Spearman correlation analyses evaluated the relationships between indoor air pollutant concentrations and respiratory symptom scores.

Results

Table1shows all indoor air quality characteristics for the forty small workshops studied. The results demonstrated that concentrations of particulate matter (PM_2. Fine and coarse inhalable particles (PM_5 and PM_{10}) were found to be much higher than WHO guideline limits in most of the workshops, with 85.0% and 82.5% of the workshops reporting concentrations exceeding acceptable levels, respectively. Concentrations of carbon dioxide (CO2) exceeded the recommended limit value for indoor air (1000 ppm) in 67.5% of workshops. Sixty point zero percent of workshops had VOC concentrations over the guideline recommendations, with emissions from paints, solvents, fuels, adhesives and other chemical products frequently used in workplaces. While the average carbon monoxide levels were below recommended occupational exposure, 17.5% of workshops had levels exceeding acceptable limits. Most of the workshops were also characterized by high temperature (77.5%) and an excessive relative humidity levels (57.5%), which may impair indoor air quality and cause increased occupational discomfort among workers.

Table 1. Indoor Air Quality Indicators in Small Workshops in Babylon City, Iraq (N = 40)

Parameter	Mean ± SD	Recommended Limit (WHO/ASHRAE)	Workshops Exceeding Limit (%)
$PM_{2.5}$ (µg/m³)	54.8 ± 18.3	15 µg/m³ (24-hour WHO)	85.0
PM_{10} (µg/m³)	112.6 ± 34.7	45 µg/m³ (24-hour WHO)	82.5
Carbon Monoxide (CO) (ppm)	8.4 ± 3.1	9 ppm (8-hour WHO)	17.5
Carbon Dioxide (CO_2) (ppm)	1186 ± 246	1000 ppm (ASHRAE)	67.5
Relative Humidity (%)	63.8 ± 9.6	30–60%	57.5
Temperature (°C)	31.2 ± 3.4	20–26°C	77.5

NS: Non-Significant at P>0.05

Table 2 shows the frequency and percentage of workers with respiratory symptoms in the small workshops included in this study. A total of 63.0% of workers reported a respiratory symptom in the last three months, reflecting the heavy burden of respiratory morbidity among our working population. The most common symptoms reported were persistent cough (41.0%), nasal irritation (38.0%), throat irritation (35.5%) and sputum production (32.5%). Respiratory symptoms including shortness of breath (28.5%), wheezing (24.0%) and chest tightness (21.5%) were also common findings.

Table 2. Prevalence of respiratory symptoms among workers in the current study

Respiratory Symptom	Number of Workers (n=200)	Percentage (%)
Persistent cough	**82**	**41.0**
Sputum production	**65**	**32.5**
Wheezing	**48**	**24.0**
Shortness of breath (Dyspnea)	**57**	**28.5**
Chest tightness	**43**	**21.5**
Nasal irritation	**76**	**38.0**
Throat irritation	**71**	**35.5**
At least one respiratory symptom	**126**	**63.0**

Table 3. Relationship Between Indoor Air Pollutant Concentrations and Presence of Respiratory Symptoms Among Workers in Small Workshops There were statistically significant associations for higher concentrations of PM_2. Presence of respiratory symptoms and particulate matter measures ($PM_{2.5}$, PM_{10}) as well as carbon dioxide (CO_2) and volatile organic compounds (VOCs). Univariable logistic regression analysis indicated that workers exposed to particulate matter concentrations higher than the levels recommended by the World Health Organization (WHO) showed a higher respiratory complaints risk compared with those who worked in an environment for which particle concentration was lower than WHO recommendation levels ($P < 0.001$). The results presented similar significant associations for increased concentrations of CO_2 and VOCs, indicating that insufficient ventilation and chemical emissions are important determinants of respiratory health in occupational settings. On the contrary, some workshop exceeded guideline levels of CO concentration but no statistically significant association was found between exposure to CO and respiratory symptoms ($P = 0.576$).

Table 3: Association Between Indoor Air Pollutants and Respiratory Symptoms

Indoor Air Pollutant	Symptomatic Workers (n = 126)	Asymptomatic Workers (n = 74)	χ^2	P-value
$PM_{2.5} > 15$ µg/m³	**118**	**52**	**24.86**	**<0.001 HS**
$PM_{10} > 45$ µg/m³	**113**	**52**	**18.79**	**<0.001 HS**
$CO_2 > 1000$ ppm	**87**	**48**	**6.47**	**0.011 S**
VOCs > 0.50 ppm	**82**	**38**	**7.95**	**0.005 HS**
CO > 9 ppm	**24**	**11**	**0.31**	**0.576 NS**

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Discussion

A major finding of this study was that 85% of workshops were above the WHO limit for PM_2. 66%, and 82.5% of the individual observations for PM_{10}. These findings indicate that in welding, grinding, cutting and other mechanical repair work conditions, workers are persistently exposed to high concentrations of inhalable dust (Li et al., 2023). Fine particulate matter can infiltrate the lung and cause innumerable injuries such as oxidative stress, airway inflammation, epithelial injury, and impairment of lung function that increase susceptibility to chronic respiratory diseases (Li et al., 2023). The American Thoracic Society too confirmed that indoor particulate pollution is a major contributor to respiratory disease and suggested action on enhancing indoor environmental quality to protect worker health (Nassikas et al., 2024).

Particulate concentrations during the present study were higher, consistent with what has been reported by Li et al. (2025), that explored the exposure of airborne particles in closed (indoor) bus maintenance workshops. In a study of aggregated occupational activities, they reported high concentrations of PM_2. $_5$ and ultrafine particles, while a ventilation and air purification system could noticeably diminish workers' exposure. The same poor working conditions can be seen in small workshops in Iraq, and if properly engineering controls are employed along with sufficient ventilation indoor air quality will significantly improve (Jones et al., 2021).

Among workers, respiratory symptoms were extremely common, with 63% reporting at least one respiratory complaint in the present study. Common symptoms included a cough, nasal and throat irritations, sputum production (what one spits), dyspnea or effort to breath, wheezing , and chest tightness. This result also correlates very well with chronic inhalation of particulate matter and chemical emissions that induce inflammation in the respiratory tract. Similar respiratory patterns have been observed in workers exposed to indoor air pollutants in occupational settings (Mack et al., 2019; Nassikas et al., 2024).

These overall relationships between particulate exposure and adverse respiratory outcomes were supported by the strong and consistent positive associations observed for both fine ($_5$) and coarse (PM10) (… Continue Reading. Workers that were exposed to PM10 concentrations larger than the recommended limit were significantly more likely to report respiratory complaints compared to those working in relatively cleaner environments. Azuma et al reported similar findings (2023), who showed that indoor–materiality matter was independently linked with agitated respiratory symptoms and worse self-rated health among office workers. Likewise, Paterson et al. (2021) concluded that indoor PM_2. Adult conditional odds ratios showed respiratory symptoms and asthma-related outcomes with significant associations of exposure to indoor PM_2.

Workers working in high particulate matter concentrations (>threshold limit) than the recommended limits were instances of respiratory complaints compared to relatively unpolluted environment. Findings similar to this were reported by Azuma et al. (2023) whose analysis found that any indoor PM was independently associated with escalating respiratory symptoms and declining perceived health among office employees. Likewise, Paterson et al. By way of example, (2021) demonstrated that indoor PM_2. Five observed a statistically significant increase in respiratory symptoms or asthma-related outcomes among adults exposed to $_5$.

Also highly relevant was the strong relationship between raised CO_2 levels and symptom presentation of the respiratory tract. In excess of 66% of the workshops investigated far exceeded the action limit for indoor concentration (1000 ppm), suggesting inadequate ventilation (Laurent & Frans, 2022). While CO_2 may not himself be particularly toxic at such concentrations, indoor CO_2 represents a relative degree of ventilation deficiency which will permit the accumulation within confined workplaces of other respiratory contaminants (Tillett, 2012). Similar observations were made by Azuma et al. (2023) through the results that associations between respirable total volatile organic compound (rTVOC) or inner particulate matter with respiratory complaints, while elevated indoor CO_2 conditions were significantly related to workplace well-being and respiratory complaints.

Moreover, the common VOCs associated with respiratory symptoms were identified in this study as well. Fuses, and cleaning agents are recognized as respiratory irritants, leading to cough and potential for wheezing, throat irritation, and dyspnea. These results are confirmed by the systematic review of Tafere et al. (2024) realized than the workers exposed to VOCs in painting-related industries presented ratios of respiratory symptoms and impaired pulmonary function much higher when compared with non-exposed. Similarly, Paterson et al. (2021) found that chronic indoor exposure to VOCs was consistently linked with increased respiratory morbidity in adults.

However, the present study found no major correlation between carbon monoxide concentration and respiratory symptoms. Environmental monitoring generally produced CO concentrations optimally below their corresponding recommended occupational exposure limits, which may partly explain the study's finding. Such observations have been also reported in occupational studies, where it has been shown that particulate matter and VOC exposure showed stronger associations with respiratory outcomes than carbon monoxide exposure (Bi et al., 2022; Nassikas et al., 2024).

Conclusions

The most common respiratory symptoms reported in this study are: Persistent cough, Sputum production and respiratory tract irritation. The study revealed evidence of association between respiratory symptoms, and most industrial facilities' poor indoor air quality among workers in small workshops in Babylon City, Iraq. Higher prevalence rate of respiratory symptoms associated with PM_5, PM_{10}, CO_2 and VOCs.

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