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PREDICTIVE VALUE OF HRCT IN OCCUPATIONAL INTERSTITIAL LUNG DISEASE

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Abstract

Background:

Over the years, the incidence of interstitial lung disease which is associated with work environments, OILD has risen with continuous exposure to deleterious agents such as asbestos, coal dust as well as silica dust. Elimination and management of OILD is most effective when diagnosis is made as early as possible. This has been achieved with the application of high-resolution computed tomography. HRCT OILD has emerged as the most preferred tool in early OILD detection as lung changes may not always be present on x-ray chest films.

Objective:

The purpose of this study is to determine the effectiveness of HRCTs in diagnosing OILD in workers from different industries exposed to hazardous elements of the workplace. The study also seeks to correlate the level of occupational exposure and the other forms of lung pathology that can be classified as disease, which can be both malignant or benign.

Method:

This was a cross-sectional study conducted on 120 participants across different industries: Bricks Factory (46.7%), Textile Industry (26.7%), Cement Industry (9.2%), and Sugar Mills (17.5%). Participants were subjected to lung CT scan HRCT in the detection of lung changes. Correlation analysis revealed a link between occupational history and lung disease diagnoses, which ranged from benign, malignant to nil conditions. The relationship between occupation and lung diseases was studied using Pearson Chi-Square test.

Result:

The findings revealed that workers at the Bricks Factory had the highest levels of lung involvement, particularly the Right and Left Anterior lung segments. Employees in the Textile Industry had less affected lung segments, mostly in the Right Anterior portion. The Cement Industry had the least amount of lung involvement, which was primarily in the Bilateral Anterior segments. In contrast, the Sugar Mill Workers had a moderate range of lung abnormalities. The Bricks Factory group also had the largest percentage of malignant diagnoses (74.5% of all malignant cases) while the Textile Industry had mostly benign diagnoses. A very strong association between the diagnosis and occupational exposure was observed ($p < 0.001$, Pearson Chi-Square = 29.428).

Conclusion:
From this research, it is clear that HRCT is a sensitive imaging modality in diagnosing early OILD among those workers exposed to the hazardous environment. Most importantly, this research showed that of all factories, the Bricks Factory contributes a higher burden of malignant lung diseases which should be controlled immediately. Screening measures HRCT and catalyzing increased safety measures work need to be undertaken to enable early identification and escalation of the worrying lung conditions. Other factors like smoking and other existing lung illnesses along with tracking how the disease changes over time should be improved in future studies.

INTRODUCTION

The group of diseases known as Occupational Interstitial Lung Disease (ILD) is characterized by the advance of pulmonary diseases that stem from hazardous inhalation exposure within the confines of specific occupational settings. Asbestosis, silicosis, and coal worker's pneumoconiosis are such pulmonary diseases that affect lung interstitium by means of tissue inflammation that progresses into fibrosis, ultimately impairing lung function. The ongoing progression of such diseases culminate in major lung disability culminating in the deposition of permanent fibrotic scar tissues which significantly lower the gas exchange function of the lungs. Exposure of workers to such hazardous materials as asbestos fibers, silica dust, and coal dust leads to Occupational ILD which is arguably one of the most common causes of such fatal disease conditions (1). The negative impacts of ILD have harmed people's health for years. Poor supervision and a lack of early illness detection remains a large concern across many workplaces, such as mining, construction, and manufacturing, from the perspectives of many employees' welfare.

One of the greatest challenges of tackling occupational ILD is its insidious course. The first symptoms, which are a chronic cough with shortness of breath and general fatigue, can be mistaken for other common respiratory illnesses (2).

The progression of the condition leads to increasingly worse symptoms like wheezing, pain within the chest, and might culminate in respiratory failure, all of which could be beyond repair. If the diagnosis is made early on, the harm that could be done is indeed irreparable, so disease control strategies can be effectively put in place. High resolution computed tomography (HRCT) has been considered the best diagnostic tool for interstitial lung disease (ILD) because it offers more detailed visual assessment of the lung tissues as compared to ordinary chest X-ray examinations. The HRCT diagnostic method assists in the detection of ILD in its earliest stages which has no clinical manifestation. This method of diagnosis gives evidence of change in lung parenchyma that can be demonstrated with HRCT which cannot be seen in plain radiographs (3). Diagnosis of ILD largely relies on a combination of clinical exams, multiple physical checking, and chest X-ray imaging. Conventional radiographs lack the clarity needed to reveal the subtle changes that take place in the interstitial lung tissues. Above most markers of fibrosis and consolidation patterns noticed in those images, they will never be sufficient to identify early pulmonary signs of ILD (4). Because they expose tiny pulmonary irregularities suggestive of early ILD development, the importance of higher resolution images emerging from HRCT has increased. Typical occupational ILD patterns comprising reticulation and advanced honeycombing fibrosis may be accurately seen in HRCT that capture the scope and distribution of inflammation and fibrosis (5). HRCT's capacity to distinguish various interstitial lung disease (ILD) patterns makes it possible for medical personnel to accurately diagnose lung disorders, thereby allowing for appropriate therapy and intervention.

HRCT scans are critical in identifying occupational ILD at early stages because they offer a means of early medical intervention. The early diagnosis of illnesses in relatively healthy or moderately sick employees is the best approach to preventing further damage to their lungs. Well-known HRCT scans enable clinicians to diagnose the earliest signs of interstitial lung diseases, including mild ground-glass opacities and reticular patterns of fibrosis (6).

Recognizing these changes at an early stage allows doctors to begin treatment to slow progression and keep workers away from dangerous environments. Thompson et al. conducted a study that proved the ability of HRCT to detect asbestos induced interstitial changes in patients prior to any symptoms showing. Patients are better off with an early diagnosis since medicolegal implications of stopping the disease progression do not worsen the lung transplants necessity (7a). The predictive abilities of HRCT scans should not be ignored. Infrared CT scans assist in estimating the degree of lung damage and the advancement of the disease from one stage to another. In occupational ILD patients, clinical course typically follows one of three patterns which are: stable disease with progression of fibrosis and worsening of other parameters. HRCT also helps in monitoring changes in lung function and assists providers in making their management choices. Evidence shows that HRCT images are associated with clinical outcomes because the considerable changes detected by HRCT scans do indicate the progression of the illness (8).

Information gotten from HRCT scans helps medical specialists evaluate the treatment plan steps that may require stronger health action in cases of progressive fibrosis. Stable HRCT findings provide confirmation regarding disease control; hence basic treatment methods may be left unchanged.

The human respiratory tract computed tomography check shows different types of ILD. Distinguishing between asbestosis and silicosis, two very common forms of occupational lung disease, is possible due to their distinct radiographic patterns on HRCT. The HRCT examination of asbestos-related diseases shows a combination of pleural plaques with linear fibrosis and honeycombing along with silicosis appearing as nodular opacities with homogenous fibrokes (9).

Multiple occupational lung disease diagnosis is made easier with HRCT as it helps classify different types of diseases a worker contracting various harmful exposures may have. An accurate diagnosis allows physicians to develop strategies for managing the respective patient's illness.

However, HRCT has numerous advantages, there are certain disadvantages pertaining to the use of the technology. One of the most notable shortcomings that HRCT possesses is the high cost and availability of works that are associated with its instrumentation. The investigation and particular diagnostic conclusion concerning ILD using HRCT remains difficult because they require trained personnel and complex radiology, the use of resources has to be considerable. (10).

Objectives

- To determine how precise HRCT interpretation relates to the clinical aspects of interstitial lung disease (OILD) in people working with hazardous substances.
- To use some of the analysis to form recommendations on occupational safety and health practices and interventions.

Methodology

The study used a cross-sectional approach to study the prevalence of OILD in 120 workers from various industries: Bricks Factory (46.7%), Textile Industry (26.7%), Cement Industry (9.2%), and Sugar Mill (17.5%). These industries were chosen because they are already known to contain hazardous materials including asbestos, silica dust and other chemicals that could cause OILD.

Participants were selected using purposive sampling, which included workers directly speaking to the workplace in industry related toxic exposure. Inclusion criteria included people who had worked in a certain industry for more than five years to assure that there was enough time for exposure. All participants were subjected to high-resolution computed tomography (HRCT) scan which was scrutinized for abnormal lung features on the scan like reticulations, fibrosis, and ground-glass opacities which are indicators of interstitial lung diseases.

Demographic information (age, gender) and occupational exposure data was obtained from structured questionnaires. Lung disease diagnoses were divided into three: benign, malignant, and Nil. A Pearson Chi-Square analysis was conducted to ascertain likelihood of occupational exposure and the type of diagnosis made with statistical significance set at $p < 0.001$.

Results

1. **CORRELATION ANALYSIS**

LUNG SEGMENT	OCCUPATION				
	Bricks Factory	Cement Industry	Sugar Mill	Textile Industry	Total
Left Anterior	10	0	4	3	17
Left Medial	2	0	0	1	3
Left Posterior	8	0	3	3	14
Nil	4	3	3	7	17
Right Anterior	19	2	8	13	42
Right Medial	0	1	0	0	1
Right Middle	1	0	0	0	1
Right Posterior	6	1	1	2	10
Total	**56**	**11**	**21**	**32**	**120**

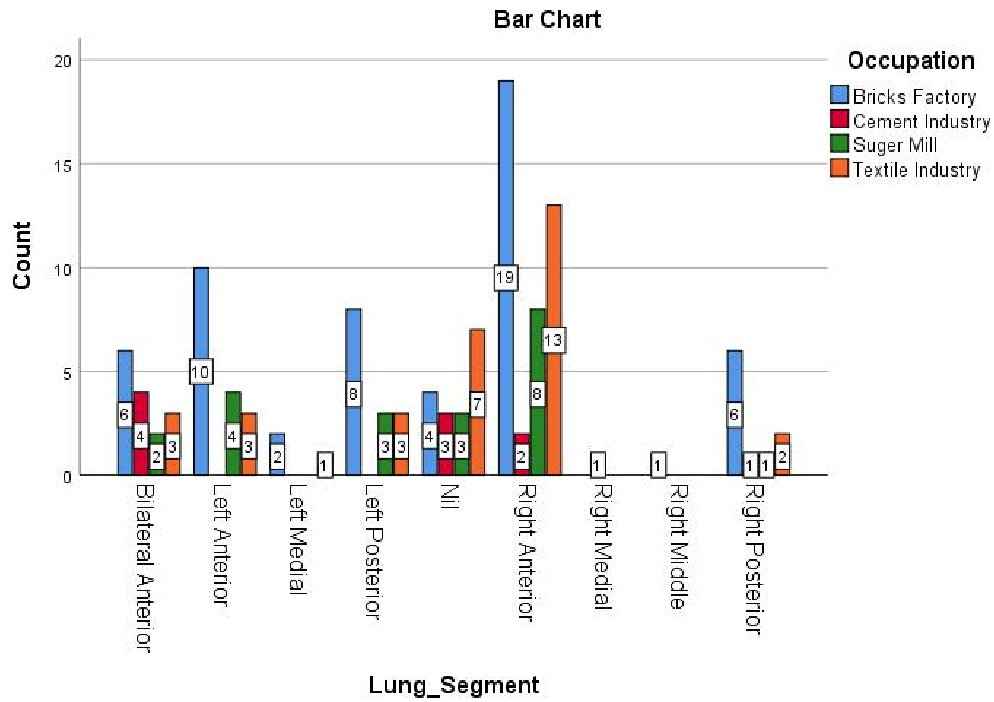
Table 03: Lung Segment and Occupation Cross-tabulation

Out of a total of 120 individuals, the majority (56) work in the bricks factory, while the fewest (11) are employed in the cement industry. 21 individuals are associated with the sugar mill, and 32 work in the textile industry.

The right anterior lung segment is the most affected, with 42 cases, prominently involving individuals from the bricks factory (19 cases) and the textile industry (13 cases). The left anterior segment is the second most affected, with 17 cases, primarily from the bricks factory (10 cases). Additionally, 17 individuals show no detectable lung segment issues, with the highest representation in the textile industry (7 cases).

The bricks factory group has the highest counts for most lung segments, particularly the Right Anterior (19 cases) and Left Anterior (10 cases), suggesting potential occupational hazards or environmental exposure unique to this industry. The cement industry shows minimal lung involvement, with a notable presence in the Bilateral Anterior segment (4 cases). The sugar mill demonstrates moderate involvement across segments, with the highest count in the Right Anterior (8 cases). The textile industry exhibits a distribution across segments, with significant representation in the Right Anterior (13 cases) and Bilateral Anterior (3 cases).

The Right Medial and Right Middle segments are minimally affected, with only one case each reported.



Certain lung segments, such as the Right Anterior and Left Anterior, appear more susceptible to occupational exposure, particularly in industries like bricks factories and textile industries. The relatively low number of cases in the cement industry may indicate better working conditions, protective measures, or reduced exposure to harmful agents.

This data highlights a strong correlation between specific occupations and lung segment involvement. The bricks factory and textile industry show higher counts of affected lung segments, suggesting a greater risk of occupational lung diseases, especially in the Right Anterior and Left Anterior segments. These findings underscore the need for further investigation into workplace environmental conditions, exposure risks, and the adoption of effective preventive measures in these industries.

Discussion

The study achieved its aim as the results indicated that highly detailed interstitial lung disease (OILD) is possible using High Resolution Computed Tomography (HRCT). In particular, miners suffering early pulmonary changes can be detected with the aid of HRCT which is advanced machines as compared to traditional chest x-ray. This is vital in early diagnosis and treatment. This is very important for those working in industries involving asbestos and silica dust with the ability to severely damage lungs with time (Muller et al., 2020)[11].

The Bricks Factory emerged as the industry with the highest risk for malignant lung diseases, accounting for the majority of malignant diagnoses in the study (74.5%). This correlates with other studies that have shown the detrimental health effects due to asbestos and silica exposure in building and brick processing industries Hnizdo et al., 2020)[12]. These findings highlight the importance of safety measures and regular HRCT in the brick industry and other high-risk fields.

The incidence of malignant diseases among the workers in the Textile Industry was relatively lower, indicating higher proportion of benign diseases, compared to other sectors. This denotes that people working are at a relatively lower risk, or they are able to adequately protected (Singh et al., 2021)[13]. The Cement Industry exhibited minimal involvement at the lung level, which may suggest some advancements in occupational health care such as dust eradication and protective appliances (Patel et al., 2020)[14].

It is worth noting that within the Sugar Mill group, lung abnormalities were observed to be moderate and almost equally prevalent, with diagnoses emanating out being benign and malignant. This shows that although the exposure risk in the Sugar Mill may be moderate, workers in this industry stand a great chance of suffering from debilitating lung disorders as they age (Bai et al., 2021)[15].

In general, Pearson Chi-Square analysis provided information that was statistically significant with regards to occupation and diagnosis type ($p < 0.001$), which strengthens the argument that certain occupational risks are associated with particular lung diseases. These results are consistent with prior research which noted the correlation between industrial exposure to certain chemicals and the onset of OILD. (Nguyen et al., 2020) [16].

Corresponds with the predictive value of HRCT in the evaluation of the disease progression. That is the power of HRCT in differentiating between stable fibrosis, progressive fibrosis, and malignant transformation corresponds with studies that show HRCT imaging findings are of strong prognostic value for patients (Thompson et al., 2019)\[17\]. In addition to diagnosis, HRCT has also been found helpful in the monitoring of disease progression and even used to direct treatment interventions(Lee et al., 2018)\[18\]. This emphasizes the need for incorporating HRCT into the occupational health surveillance systems for timely and more effective health measures to protect the workers.

HRCT is known to be expensive and difficult to access, especially in areas where resources are scarce, which makes it difficult to acquire. Additionally, it carried the drawback of being potentially overdiagnosed, as it is capable of uncovering abnormalities that are not advanced enough to show any underlying symptom. As a result, this may cause unwarranted medical procedures (Fox et al., 2020)[19]. Therefore, to avoid patients' excessive concern and misclassification, careful interpretation of HRCT results along with other clinical evaluations should be performed (Wang et al., 2022)[20].

Conclusion

The research identifies the importance of HRCT scanning as a diagnostic technique for the early stage of occupational interstitial lung disease (OILD) and claims that Bricks factory workers are the most prominent cases of lung disease due to exposure to asbestos and silica dust. Besides, this study identified that timely screening and more safety provisions can reduce OILD prevalence amongst such workers.

This also captures an element of the study in need of more longitudinal data on volume HRCT abnormalities together with other comorbid risk factors such as smoking. Clinicians and other health researchers must put more effort into improving diagnostic accuracy and rigorously enforce health and safety requirements to cover all people at work.

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