

Diagnostic Utility of HRCT Chest in Detecting Pulmonary Pathologies Among Symptomatic Smokers

M. Noor-ul-Hassan Butt¹, Hafiza Maria Fawad² , Tayyaba Iqbal³, Musfirah Khalid¹, Hira Nadeem¹, Atiqa Aziz¹, Syeda Eman Shah¹, Mubashir Farhan¹

¹ Al Razi Institute, Lahore, Pakistan

² Head of Department, Radiography & Imaging Technology, Al Razi Institute, Lahore, Pakistan

³ Lecturer of Radiography & Imaging Technology, Al Razi Institute, Lahore, Pakistan

*Corresponding author: Hafiza Maria Fawad, mariafawad20@gmail.com

ORCID ID: 0009-0007-8081-9110

Cite this Article Received: 07 January 2026; Accepted: 09 February 2026; Published: 15 March 2026

Author Contributions: Concept: MNHB, HMF; Design: HMF, TI; Data Collection: MK, HN, AA, SES, MF; Analysis: MNHB, HMF, TI; Drafting: MNHB, HMF, TI, MK, HN, AA, SES, MF. **Ethical Approval:** Al Razi Institute, Lahore, Pakistan. **Informed Consent:** Written informed consent was obtained from all participants; **Conflict of Interest:** The authors declare no conflict of interest. **Funding:** No external funding; **Data Availability:** Available from the corresponding author on reasonable request; **Acknowledgments:** N/A.

ABSTRACT

Background: Chronic tobacco smoking is associated with multiple pulmonary abnormalities, including emphysema, respiratory bronchiolitis, pulmonary tuberculosis, lung nodules, pneumothorax, and interstitial lung disease. Early structural abnormalities may be difficult to characterize using routine clinical assessment alone, particularly in symptomatic smokers with chronic cough, sputum production, dyspnoea, or haemoptysis. **Objective:** To determine the frequency and anatomical distribution of HRCT-detected pulmonary abnormalities among symptomatic adult smokers. **Methods:** This prospective observational imaging study was conducted at Lahore General Hospital over 90 days and included 93 adult current smokers with respiratory symptoms and a cumulative exposure of at least 10 pack-years. Clinical symptoms, smoking exposure, family history, HRCT-detected pulmonary abnormalities, and lung-zone involvement were recorded using a structured data collection approach. Data were analyzed descriptively using SPSS version 27. **Results:** The mean age was 52.72 ± 13.40 years, mean smoking duration was 23.32 ± 10.60 years, and mean pack-year exposure was 18.14 ± 7.03 . Cough was reported by 74 participants (79.6%), sputum production by 70 (75.3%), dyspnoea by 69 (74.2%), and haemoptysis by 20 (21.5%). HRCT showed emphysema in 59 participants (63.4%), pulmonary tuberculosis-related radiological abnormalities in 30 (32.3%), respiratory bronchiolitis in 15 (16.1%), pneumothorax in 2 (2.2%), and lung nodules in 2 (2.2%). Middle-zone involvement was most frequent, occurring in 29 participants (31.2%). **Conclusion:** HRCT identified a substantial burden of pulmonary abnormalities among symptomatic smokers, particularly emphysema, tuberculosis-related radiological abnormalities, and respiratory bronchiolitis. These findings support HRCT as a useful anatomical imaging modality in clinically selected symptomatic smokers, while formal diagnostic accuracy requires comparison with an independent reference standard. **Keywords:** High-Resolution Computed Tomography, Symptomatic Smokers, Emphysema, Respiratory Bronchiolitis, Pulmonary Tuberculosis, Lung Nodules, Pneumothorax, Smoking-Related Lung Disease

INTRODUCTION

Tobacco smoking remains one of the most important preventable contributors to respiratory morbidity, with established links to chronic obstructive pulmonary disease, emphysema, respiratory bronchiolitis, interstitial lung disease, pulmonary tuberculosis, pulmonary nodules, pneumothorax, and lung cancer. The inhaled toxic constituents of tobacco smoke produce persistent airway and parenchymal injury through oxidative stress, epithelial damage, inflammatory-cell recruitment, macrophage activation, protease-antiprotease imbalance, and progressive remodeling of the small airways and alveolar

structures. These mechanisms may remain clinically silent during the early stages of disease, particularly in smokers who present only with chronic cough, sputum production, exertional dyspnoea, or intermittent haemoptysis, resulting in delayed recognition until structural lung damage has advanced (1,2).

The clinical evaluation of symptomatic smokers is challenging because respiratory symptoms are often nonspecific and may be attributed to aging, recurrent bronchitis, environmental exposure, or poor physical conditioning. Even smokers who do not meet spirometric criteria for chronic obstructive pulmonary disease may have radiological abnormalities, impaired respiratory health status, reduced exercise tolerance, and early structural lung changes. Conventional chest radiography has value as an initial imaging modality, but it has limited ability to detect subtle emphysematous change, small-airway disease, early interstitial abnormality, and small pulmonary nodules. Spirometry provides functional information, but early smoking-related parenchymal and small-airway abnormalities may precede measurable airflow limitation. This diagnostic gap supports the need for imaging techniques that can characterize early lung changes in clinically selected smokers with persistent respiratory symptoms (3,4).

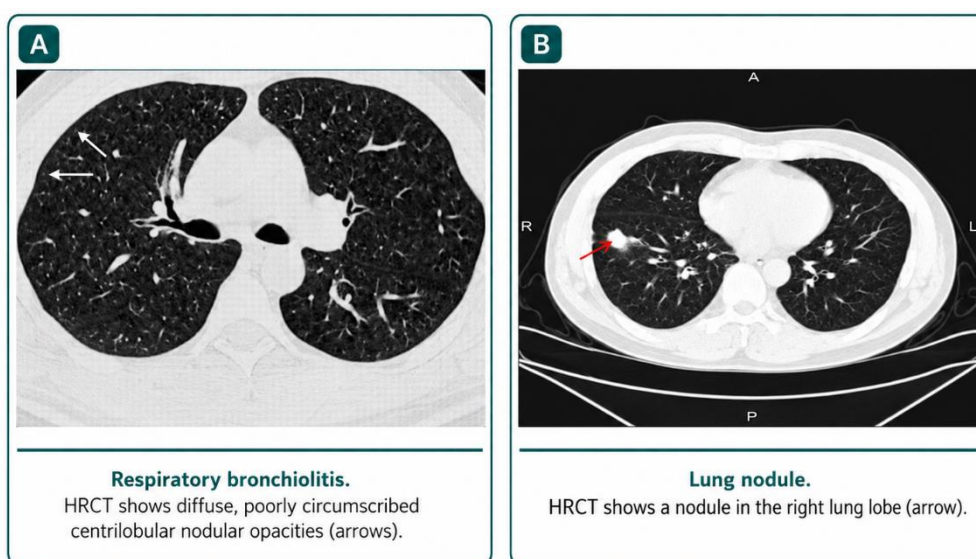


Figure 1 Respiratory Bronchiolitis and Lung Nodule

High-resolution computed tomography of the chest provides detailed visualization of the lung parenchyma, bronchioles, interstitium, pleura, and regional distribution of abnormalities. In smokers, HRCT can identify emphysematous destruction, air trapping, centrilobular nodules, ground-glass opacities, bronchial wall thickening, fibrotic change, cavitary lesions, nodular opacities, and pleural complications. Although radiation exposure and cost limit its use as an indiscriminate screening tool, HRCT has particular clinical value when symptoms persist, when radiographic findings are equivocal, or when detailed anatomical characterization is required for diagnostic planning and clinical management (5). Low-dose CT approaches have further increased interest in computed tomography-based evaluation of high-risk smokers by reducing radiation exposure while preserving diagnostic utility for several thoracic abnormalities (6).

Smoking-related interstitial and small-airway disorders represent an important component of the disease spectrum detectable on HRCT. Respiratory bronchiolitis, respiratory bronchiolitis-associated interstitial lung disease, desquamative interstitial pneumonia, pulmonary Langerhans cell histiocytosis, and idiopathic pulmonary fibrosis have all been associated with current or previous cigarette smoking. Typical HRCT patterns in smoking-related bronchiolar and interstitial disease include poorly defined centrilobular nodules, patchy ground-glass opacities, bronchial wall thickening, air trapping, and upper-zone emphysematous changes. These abnormalities may be missed or underestimated on plain radiography, particularly when disease burden is mild or distributed in a patchy pattern (7,8).

Emphysema is one of the most frequent structural consequences of chronic tobacco exposure and may be identified radiologically before advanced airflow limitation becomes clinically evident. CT-based detection of emphysema is clinically meaningful because emphysematous change in smokers is associated with progressive airflow obstruction, increased exacerbation risk, lung cancer risk, reduced functional capacity, and mortality, even among individuals who do not yet fulfill spirometric criteria for chronic obstructive pulmonary disease. HRCT also allows recognition of the distribution and morphological pattern of emphysema, which may help differentiate smoking-related parenchymal destruction from other pulmonary processes and may support earlier risk stratification (9).

Pulmonary nodules and pneumothorax are additional clinically relevant findings in smokers. A pulmonary nodule is defined radiologically as a rounded or irregular opacity measuring up to 3 cm in diameter and surrounded by aerated lung, and its recognition is particularly important in smokers because tobacco exposure increases the risk of malignant transformation and lung cancer. CT is substantially more sensitive than chest radiography for detecting small nodules, although the clinical interpretation of nodules requires consideration of size, morphology, growth, and patient-level risk factors (10,11). Similarly, smoking is an important risk factor for spontaneous pneumothorax, partly through its association with emphysema-like changes, subpleural blebs, bullae, and underlying obstructive lung disease. HRCT may therefore help identify structural risk patterns and differentiate primary from secondary causes when pneumothorax is suspected (12,13).

Pulmonary tuberculosis remains a major public health problem in low- and middle-income settings, and chronic smoking may increase vulnerability by impairing mucociliary clearance, local immune defense, and pulmonary macrophage function. HRCT can demonstrate parenchymal features suggestive of active or prior tuberculosis, including centrilobular nodules, tree-in-bud opacities, consolidation, cavitation, fibrosis, bronchiectatic change, and regional lung destruction. However, HRCT findings require clinical and laboratory correlation because imaging alone cannot definitively confirm active tuberculosis. In symptomatic smokers from high-burden settings, HRCT may still provide important anatomical information that supports differential diagnosis and guides further testing (14).

Despite growing evidence on CT-detected smoking-related lung disease, local data remain limited regarding the frequency and distribution of HRCT-detected pulmonary abnormalities among symptomatic smokers in hospital-based populations. This gap is clinically important because smokers presenting with cough, sputum production, dyspnoea, or haemoptysis may have overlapping infectious, obstructive, interstitial, nodular, or pleural abnormalities, and the pattern of disease may vary according to population risk profile and regional disease burden. Therefore, this study was designed to evaluate adult symptomatic smokers with at least 10 pack-years of tobacco exposure and to determine the frequency and radiological distribution of HRCT-detected pulmonary pathologies. The objective of the study was to assess the spectrum of HRCT chest findings among symptomatic smokers and to describe the distribution of emphysema, respiratory bronchiolitis, pulmonary tuberculosis, lung nodules, pneumothorax, and lung-zone involvement in this clinically selected population.

MATERIAL AND METHODS

This prospective observational imaging study was conducted at Lahore General Hospital over a period of 90 days after approval of the synopsis. The study was designed to evaluate the spectrum of high-resolution computed tomography chest findings among adult symptomatic smokers and to describe the frequency and anatomical distribution of pulmonary abnormalities detected on HRCT. The study population comprised adult current smokers who presented with respiratory symptoms warranting chest imaging and who had a cumulative smoking exposure of at least 10 pack-years. The population, exposure, and outcome framework was based on symptomatic adult smokers as the target population, chronic smoking exposure as the clinical risk factor, HRCT chest as the imaging assessment, and HRCT-detected pulmonary abnormalities as the primary outcome.

Participants were selected from clinically eligible patients referred for chest imaging. Adults aged 18 years or older were included if they were current smokers, had a smoking history of at least 10 pack-years, presented with respiratory symptoms such as chronic cough, unexplained dyspnoea, haemoptysis, or persistent sputum production, and were able to provide written informed consent. A clinician request for chest imaging was required so that HRCT assessment was clinically justified. Patients were excluded if they had a known previously treated diagnosis of lung cancer, active pulmonary tuberculosis already under treatment, established interstitial lung disease, acute respiratory infection within the preceding four weeks unless tuberculosis was clinically suspected, pregnancy, lactation, inability to cooperate with CT breath-holding instructions, or severe comorbidity likely to prevent clinically meaningful assessment or follow-up.

The sample size was calculated using the single-population proportion formula, $n = Z^2p(1 - p)/E^2$, where the confidence level was set at 95%, the standard normal deviate was 1.96, the expected prevalence was 60%, and the margin of error was 10%. This calculation produced a required sample size of 93 participants, and all 93 eligible symptomatic smokers were included in the final analysis. Smoking exposure was assessed through participant history and quantified using smoking duration, number of cigarettes smoked per day, and pack-years. Pack-years were calculated from the average number of cigarette packs smoked per day multiplied by the number of years of smoking exposure.

Data were collected using a structured clinical and imaging record. Demographic variables included age and smoking-related variables, including duration of smoking, cigarettes per day, and cumulative pack-years. Clinical variables included cough, sputum production, haemoptysis, dyspnoea, smoking history, and family history. HRCT imaging variables included the presence or absence of emphysema, respiratory bronchiolitis, pneumothorax, lung nodules, and pulmonary tuberculosis-related radiological abnormalities. Lung-zone involvement was recorded according to the dominant anatomical distribution of abnormality as upper, middle, lower, or diffuse involvement. Pulmonary conditions were recorded as non-mutually exclusive HRCT findings, allowing more than one abnormality to be documented in the same participant when present.

HRCT chest examinations were performed using thin-section chest imaging protocols suitable for assessment of lung parenchymal and small-airway abnormalities. Imaging assessment focused on radiological features relevant to smoking-related and infectious pulmonary disease, including emphysematous change, air trapping, centrilobular nodules, ground-glass opacities, bronchial wall thickening, interstitial abnormality, pulmonary nodules, pneumothorax, and features suggestive of pulmonary tuberculosis. HRCT-based identification of tuberculosis was interpreted as a radiological finding requiring clinical correlation rather than a standalone microbiological diagnosis. Imaging findings were documented in a standardized format to ensure consistency across participants.

Bias was addressed by applying predefined eligibility criteria, enrolling participants according to the same clinical and smoking-exposure criteria, using a uniform data collection approach, and recording HRCT abnormalities according to prespecified categories. Confounding was considered during interpretation by documenting age, smoking duration, cigarettes per day, pack-years, respiratory symptoms, family history, and lung-zone distribution. Because the study was descriptive and observational, the analysis focused on estimating the burden and distribution of HRCT-detected abnormalities rather than making causal claims or calculating diagnostic accuracy indices.

Data were entered and analyzed using SPSS version 27. Continuous variables, including age, duration of smoking, cigarettes per day, and pack-years, were summarized using mean, standard deviation, minimum, and maximum values. Categorical variables, including respiratory symptoms, family history, HRCT-detected pulmonary conditions, and lung-zone involvement, were summarized as frequencies and percentages using the total sample size as the denominator unless otherwise specified. Missing or incomplete values were reviewed before analysis, and available-case analysis was applied for variables

with complete denominators. The analysis was restricted to descriptive statistics because no independent reference standard was used for formal diagnostic accuracy estimation.

The study was conducted after institutional approval of the synopsis, and written informed consent was obtained from eligible participants before data collection. HRCT was performed only in participants for whom chest imaging was clinically justified. Participant confidentiality was maintained during data handling, and study records were used only for research analysis. Data integrity was supported through standardized data extraction, consistent variable coding, verification of entered values against source records, and analysis using a predefined descriptive statistical plan.

RESULTS

A total of 93 symptomatic adult smokers were included in the study. The mean age of participants was 52.72 ± 13.40 years, with an age range of 30 to 75 years. The mean duration of smoking was 23.32 ± 10.60 years, ranging from 5 to 40 years. The cumulative smoking exposure ranged from 10.1 to 41.4 pack-years, with a mean exposure of 18.14 ± 7.03 pack-years. The mean daily cigarette consumption was 14.13 ± 5.62 cigarettes per day, with reported values ranging from 5 to 25 cigarettes per day.

Table 1. Demographic and Smoking-Exposure Characteristics of Participants

Variable	N	Minimum	Maximum	Mean \pm SD
Age, years	93	30	75	52.72 ± 13.40
Duration of smoking, years	93	5	40	23.32 ± 10.60
Pack-years	93	10.1	41.4	18.14 ± 7.03
Cigarettes per day	93	5	25	14.13 ± 5.62

SD, standard deviation.

The study population represented a middle-aged to older group of symptomatic smokers with prolonged tobacco exposure. Although smoking duration varied widely, all participants met the minimum cumulative exposure criterion of at least 10 pack-years. The mean pack-year exposure of 18.14 ± 7.03 indicates a substantial accumulated smoking burden, while the mean daily cigarette consumption of 14.13 ± 5.62 cigarettes per day reflects moderate to heavy ongoing tobacco use in this clinically selected population.

Respiratory symptoms were common among the included participants. Cough was reported by 74 participants, sputum production by 70 participants, dyspnoea by 69 participants, and haemoptysis by 20 participants. All participants were current smokers. A positive family history was reported by 33 participants, while 60 participants reported no family history.

Table 2. Clinical Symptoms and Family History Among Participants

Variable	Category	n (%)
Cough	No	19 (20.4)
Cough	Yes	74 (79.6)
Sputum production	No	23 (24.7)
Sputum production	Yes	70 (75.3)
Haemoptysis	No	73 (78.5)
Haemoptysis	Yes	20 (21.5)
Dyspnoea	No	24 (25.8)
Dyspnoea	Yes	69 (74.2)
Smoking history	Smoker	93 (100.0)
Family history	No	60 (64.5)
Family history	Yes	33 (35.5)

Percentages were calculated using N = 93 as the denominator.

Cough was the most frequently reported symptom, affecting 79.6% of participants, followed by sputum production in 75.3% and dyspnoea in 74.2%. Haemoptysis was less frequent but clinically relevant, being present in 21.5% of participants. The high frequency of cough, sputum production, and dyspnoea indicates a substantial symptomatic respiratory burden among the smokers included in the study. A

positive family history was reported in 35.5% of participants, suggesting that more than one-third of the sample had an additional familial risk context alongside chronic tobacco exposure.

HRCT chest identified several pulmonary abnormalities among symptomatic smokers. Emphysema was the most common HRCT finding and was present in 59 participants. Pulmonary tuberculosis-related radiological abnormalities were reported in 30 participants. Respiratory bronchiolitis was identified in 15 participants. Pneumothorax and lung nodules were uncommon, each being detected in 2 participants.

Table 3. HRCT-Detected Pulmonary Conditions Among Participants

HRCT Finding	No, n (%)	Yes, n (%)
Emphysema	34 (36.6)	59 (63.4)
Respiratory bronchiolitis	78 (83.9)	15 (16.1)
Pneumothorax	91 (97.8)	2 (2.2)
Lung nodules	91 (97.8)	2 (2.2)
Pulmonary tuberculosis-related radiological abnormalities	63 (67.7)	30 (32.3)

HRCT, high-resolution computed tomography. Percentages were calculated using N = 93 as the denominator. Findings were recorded as non-mutually exclusive radiological abnormalities.

Emphysema was the dominant HRCT-detected abnormality, affecting 63.4% of symptomatic smokers. Pulmonary tuberculosis-related radiological abnormalities were the second most frequent finding, observed in 32.3% of participants, while respiratory bronchiolitis was present in 16.1%. Pneumothorax and lung nodules were both infrequent, each occurring in 2.2% of participants. Because HRCT findings were recorded as non-mutually exclusive abnormalities, participants could have more than one pulmonary finding. These results indicate that emphysematous change was the principal radiological abnormality in this symptomatic smoking population, with a notable additional burden of tuberculosis-related imaging findings.

The distribution of lung-zone involvement varied across participants. Middle-zone involvement was recorded in 29 participants. Diffuse and upper-zone involvement were each observed in 22 participants, while lower-zone involvement was recorded in 20 participants.

Table 4. Distribution of Lung-Zone Involvement on HRCT

Lung Zone	n (%)	Cumulative %
Diffuse	22 (23.7)	23.7
Upper	22 (23.7)	47.3
Middle	29 (31.2)	78.5
Lower	20 (21.5)	100.0

HRCT, high-resolution computed tomography. Percentages were calculated using N = 93 as the denominator.

Middle-zone involvement was the most frequently recorded anatomical distribution, accounting for 31.2% of cases. Diffuse and upper-zone involvement each accounted for 23.7%, while lower-zone involvement was the least frequent pattern at 21.5%. The distribution suggests that abnormalities were not confined to a single classic smoking-related upper-zone pattern and that a mixed radiological distribution was present in this symptomatic hospital-based smoking population.

Overall, HRCT detected a high burden of pulmonary abnormalities among symptomatic smokers, with emphysema being the most frequent finding, followed by pulmonary tuberculosis-related radiological abnormalities and respiratory bronchiolitis. The symptom profile was dominated by cough, sputum production, and dyspnoea, while haemoptysis was less common. Lung-zone involvement showed a relatively mixed pattern, with middle-zone involvement being the most frequent distribution. The findings support the descriptive value of HRCT in characterizing the burden and anatomical pattern of pulmonary abnormalities among clinically selected symptomatic smokers.

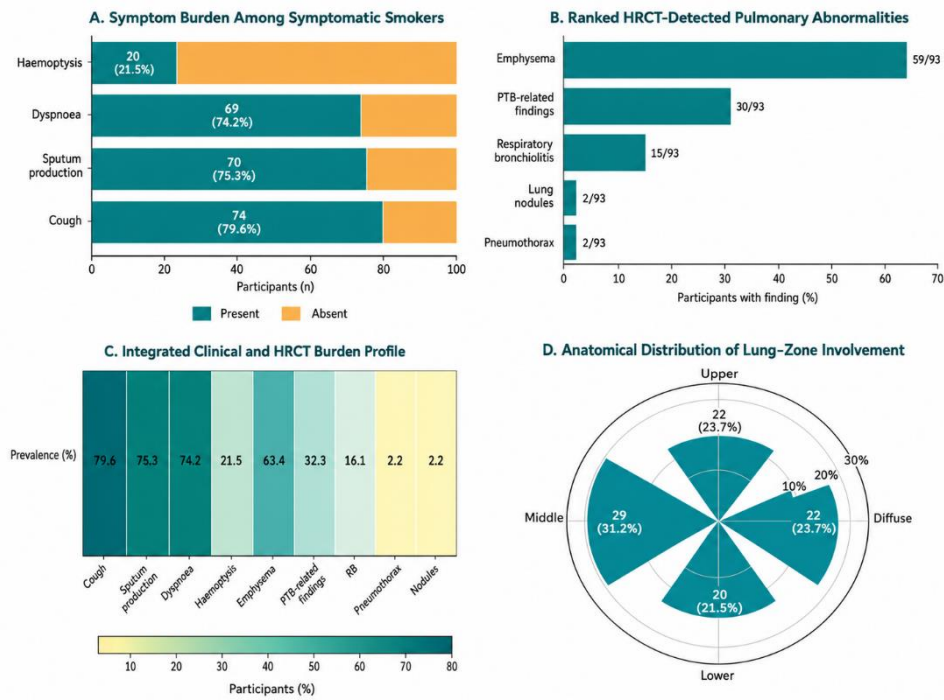


Figure 2 Clinical Symptom Burden, HRCT Abnormality Pattern, and Lung-Zone Distribution

Clinical Symptom Burden, HRCT Abnormality Pattern, and Lung-Zone Distribution in Symptomatic Smokers. Panel A shows the distribution of respiratory symptoms among 93 symptomatic smokers, with cough reported by 74 participants (79.6%), sputum production by 70 (75.3%), dyspnoea by 69 (74.2%), and haemoptysis by 20 (21.5%). Panel B ranks HRCT-detected pulmonary abnormalities, showing emphysema as the dominant finding in 59 participants (63.4%), followed by pulmonary tuberculosis-related radiological abnormalities in 30 (32.3%), respiratory bronchiolitis in 15 (16.1%), pneumothorax in 2 (2.2%), and lung nodules in 2 (2.2%). Panel C integrates the clinical and radiological burden profile, demonstrating that the highest symptom frequencies clustered around cough, sputum production, and dyspnoea, while the highest HRCT abnormality burden was emphysema. Panel D displays the anatomical distribution of lung-zone involvement, with middle-zone involvement being most frequent in 29 participants (31.2%), followed by diffuse and upper-zone involvement in 22 participants each (23.7%) and lower-zone involvement in 20 participants (21.5%).

DISCUSSION

The present prospective observational imaging study evaluated HRCT-detected pulmonary abnormalities among 93 symptomatic adult smokers with a cumulative exposure of at least 10 pack-years. The study population was predominantly middle-aged to older, with a mean age of 52.72 ± 13.40 years, mean smoking duration of 23.32 ± 10.60 years, and mean cumulative exposure of 18.14 ± 7.03 pack-years. This profile is clinically important because chronic tobacco exposure is associated with progressive airway inflammation, alveolar destruction, interstitial injury, and impaired host defense, all of which may contribute to heterogeneous pulmonary abnormalities in symptomatic smokers. The high frequency of respiratory symptoms in the current cohort, particularly cough, sputum production, and dyspnoea, supports the clinical relevance of detailed thoracic imaging in selected smokers with persistent respiratory complaints. These findings are consistent with previous evidence showing that smokers may have clinically meaningful respiratory symptoms and radiological disease even when early structural changes are not fully captured by routine functional or plain radiographic assessment (3,4).

Cough was the most frequent symptom in this study, affecting 79.6% of participants, followed by sputum production in 75.3% and dyspnoea in 74.2%. Haemoptysis was less common but was still reported by 21.5% of participants. This symptom pattern reflects the expected clinical burden of chronic smoking-

related airway irritation and parenchymal disease, in which chronic cough and sputum production may reflect bronchitic airway involvement, while dyspnoea may indicate emphysematous, bronchiolar, interstitial, or infectious pathology. Regan et al. emphasized that many smokers experience respiratory symptoms and radiological abnormalities despite not meeting conventional spirometric thresholds for chronic obstructive pulmonary disease, highlighting the limitation of relying on functional classification alone in symptomatic smokers (3). Similarly, Keesara et al. described the clinical usefulness of HRCT in symptomatic smokers with chronic cough, dyspnoea, and unexplained respiratory findings, particularly when a more detailed parenchymal assessment is required (4).

Emphysema was the most frequent HRCT-detected abnormality in the present study, being identified in 59 of 93 participants, corresponding to 63.4% of the cohort. This finding is biologically plausible because cigarette smoke promotes oxidative injury, alveolar wall destruction, inflammatory protease activity, and distal airspace enlargement, leading to structural emphysematous change over time. The observed predominance of emphysema is also consistent with studies reporting CT-detected emphysematous abnormalities among smokers, including those with normal or near-normal pulmonary function. Bhat et al. reported that HRCT could detect smoking-induced lung damage among smokers with normal pulmonary function tests, while Reddy et al. found emphysematous changes in a substantial proportion of smokers with normal chest radiographs (15,16). Steiger et al. further emphasized that CT-detected emphysema has clinical relevance because it may identify smokers at increased risk even when chronic obstructive pulmonary disease has not been previously diagnosed (9). In the present study, the high emphysema burden therefore reinforces the value of HRCT as a descriptive imaging modality for anatomical characterization of smoking-related lung damage in clinically selected symptomatic smokers.

Pulmonary tuberculosis-related radiological abnormalities were reported in 30 participants, representing 32.3% of the sample. This proportion is notable and may reflect the local epidemiological context, where tuberculosis remains a major public health concern, alongside the increased susceptibility to respiratory infection associated with chronic smoking. Smoking can impair mucociliary clearance, alter macrophage function, and compromise local pulmonary immunity, thereby increasing vulnerability to tuberculosis infection and disease progression. Dayaakar and Babu described HRCT as useful in identifying early and subtle pulmonary tuberculosis patterns, including parenchymal and bronchiolar abnormalities that may not be fully characterized on conventional radiography (14). However, the present study appropriately interprets tuberculosis-related findings as radiological abnormalities requiring clinical and laboratory correlation, rather than definitive microbiological confirmation based on HRCT alone. This distinction is important because imaging features such as nodules, consolidation, cavitation, fibrosis, and tree-in-bud opacities may support suspicion of pulmonary tuberculosis but cannot independently establish active disease without microbiological or clinical confirmation.

Respiratory bronchiolitis was identified in 15 participants, corresponding to 16.1% of the cohort. This finding is clinically meaningful because respiratory bronchiolitis is closely associated with smoking and may remain subclinical or present with nonspecific symptoms such as cough and exertional dyspnoea. Smoking-related bronchiolar disease typically appears on HRCT as centrilobular nodules, ground-glass opacities, bronchial wall thickening, and air trapping, often with upper-lobe predominance. Meka and Rao described HRCT as valuable for recognizing smoking-related interstitial and bronchiolar lung disease, while Margaritopoulos et al. emphasized the close association of smoking with respiratory bronchiolitis-associated interstitial lung disease and related interstitial patterns (7,8). The lower frequency of respiratory bronchiolitis compared with emphysema in the present study may reflect differences in diagnostic categorization, disease visibility, clinical referral patterns, or overlap between emphysematous and bronchiolar abnormalities. Because the present data are aggregated, the coexistence of respiratory bronchiolitis with emphysema or other HRCT findings could not be examined statistically.

Pneumothorax and lung nodules were uncommon in this cohort, each being detected in 2 participants, corresponding to 2.2% of the study population. Although infrequent, both findings remain clinically important in smokers. Smoking is associated with spontaneous pneumothorax through emphysema-like changes, bleb formation, bullae, and underlying obstructive pathology. Hobbs et al. reported that pneumothorax risk is influenced by smoking-related structural abnormalities, while Ruppert et al. highlighted the role of computed tomography in identifying secondary causes of spontaneous pneumothorax when chest radiography may be insufficient (12,13). Pulmonary nodules also require careful interpretation in smokers because tobacco exposure is a major risk factor for malignant pulmonary lesions. Larici et al. emphasized that nodule size and morphology remain central to radiological risk assessment, and Patel et al. described the role of low-dose CT in detecting pulmonary nodules in smokers (6,10). The low nodule frequency in the present study may be due to the limited sample size, short recruitment duration, symptom-based rather than screening-based inclusion, or local referral characteristics.

The distribution of lung-zone involvement showed a mixed anatomical pattern, with middle-zone involvement being most frequent at 31.2%, followed by diffuse and upper-zone involvement at 23.7% each and lower-zone involvement at 21.5%. Classic smoking-related emphysema and respiratory bronchiolitis often demonstrate upper-zone predominance, particularly when centrilobular emphysema or respiratory bronchiolitis-associated changes are present (7,8). However, the present study found a higher proportion of middle-zone involvement, which may reflect the coexistence of smoking-related disease with tuberculosis-related radiological abnormalities in this cohort. Pulmonary tuberculosis may involve variable lung zones depending on disease stage, host factors, and reactivation pattern, and mixed infectious and smoking-related abnormalities may therefore produce a less typical distribution than a cohort composed exclusively of chronic obstructive or interstitial smoking-related lung disease. This finding supports the need to interpret HRCT patterns within the local clinical and epidemiological context rather than assuming a single disease pathway.

The present study has several strengths. It focused on a clinically relevant population of symptomatic smokers, applied a minimum cumulative smoking exposure threshold, and documented a broad spectrum of HRCT-detected pulmonary abnormalities rather than limiting assessment to a single disease category. The study also reported both clinical symptoms and anatomical zone distribution, allowing a descriptive overview of respiratory burden and radiological patterns in this hospital-based population. However, several limitations must be considered. The sample size was modest, the study was conducted at a single center, and the recruitment period was limited to 90 days, which may restrict generalizability and reduce the likelihood of detecting uncommon abnormalities such as pneumothorax and pulmonary nodules. The analysis was descriptive, and no participant-level cross-tabulations were available to examine associations between age, pack-years, symptoms, and HRCT findings. Most importantly, the study did not use an independent reference standard; therefore, sensitivity, specificity, predictive values, and formal diagnostic accuracy measures could not be calculated. Pulmonary tuberculosis-related abnormalities were based on radiological findings and should be interpreted as requiring clinical and microbiological correlation.

Overall, the findings indicate that HRCT identified a substantial burden of pulmonary abnormalities among symptomatic smokers, with emphysema being the dominant radiological finding, followed by tuberculosis-related abnormalities and respiratory bronchiolitis. The study supports the role of HRCT as a detailed anatomical imaging modality for characterizing pulmonary abnormalities in clinically selected symptomatic smokers, while also highlighting the need for larger multicenter studies with standardized imaging protocols, microbiological correlation where infection is suspected, and participant-level analytical models examining the relationship between smoking exposure, symptom burden, and specific HRCT abnormalities.

CONCLUSION

HRCT chest demonstrated a high burden of pulmonary abnormalities among symptomatic adult smokers with at least 10 pack-years of tobacco exposure, with emphysema identified as the most frequent finding, followed by pulmonary tuberculosis-related radiological abnormalities and respiratory bronchiolitis. Cough, sputum production, and dyspnoea were the dominant clinical symptoms, while haemoptysis was less frequent but clinically relevant. Lung-zone involvement showed a mixed distribution, with middle-zone involvement being the most common pattern. These findings support the clinical value of HRCT for detailed anatomical characterization of pulmonary abnormalities in selected symptomatic smokers; however, because no independent reference standard was used, the results should be interpreted as descriptive imaging findings rather than formal diagnostic accuracy evidence.

REFERENCES

1. West R. Tobacco smoking: health impact, prevalence, correlates and interventions. *Psychol Health*. 2017;32(8):1018-1036.
2. Kumar A, Cherian SV, Vassallo R, Yi ES, Ryu JH. Current concepts in pathogenesis, diagnosis, and management of smoking-related interstitial lung diseases. *Chest*. 2018;154(2):394-408.
3. Regan EA, Lynch DA, Curran-Everett D, Curtis JL, Austin JH, Grenier P-A, et al. Clinical and radiologic disease in smokers with normal spirometry. *JAMA Intern Med*. 2015;175(9):1539-1549.
4. Keesara M, Bangaru B, Srujana P. Low-dose HRCT thorax for early detection of pulmonary pathologies in symptomatic smokers: a cross-sectional evaluation. *Journal of Contemporary Clinical Practice*. 2025;11:783-787.
5. Tækker M, Kristjánisdóttir B, Graumann O, Laursen CB, Pietersen PI. Diagnostic accuracy of low-dose and ultra-low-dose CT in detection of chest pathology: a systematic review. *Clin Imaging*. 2021;74:139-148.
6. Patel D, Deepthi M, Mishra S. Evaluation of low-dose CT accuracy in detecting pulmonary nodules in smokers. *European Journal of Cardiovascular Medicine*. 2025;15:13-15.
7. Meka S, Rao DA. Role of HRCT in smoking related interstitial lung diseases. *IAIM*. 2019;6(8):78-94.
8. Margaritopoulos GA, Vasarmidi E, Jacob J, Wells AU, Antoniou KM. Smoking and interstitial lung diseases. *Eur Respir Rev*. 2015;24(137):428-435.
9. Steiger D, Siddiqi ME, Yip R, Yankelevitz DE, Henschke CI, Jirapatnakul A, et al. The importance of low-dose CT screening to identify emphysema in asymptomatic participants with and without a prior diagnosis of COPD. *Clin Imaging*. 2021;78:136-141.
10. Larici AR, Farchione A, Franchi P, Ciliberto M, Cicchetti G, Calandriello L, et al. Lung nodules: size still matters. *Eur Respir Rev*. 2017;26(146).
11. Jia T, Zhao DZ, Yang JZ, Wang X. Automated detection of pulmonary nodules in HRCT images. In: 2007 1st International Conference on Bioinformatics and Biomedical Engineering; 2007 Jul. p. 833-836.
12. Ruppert AM, Sroussi D, Khallil A, Giot M, Assouad J, Cadranel J, et al. Detection of secondary causes of spontaneous pneumothorax: comparison between computed tomography and chest X-ray. *Diagn Interv Imaging*. 2020;101(4):217-224.

13. Hobbs BD, Foreman MG, Bowler R, Jacobson F, Make B, Castaldi PJ, et al. Pneumothorax risk factors in smokers with and without chronic obstructive pulmonary disease. *Ann Am Thorac Soc*. 2014;11(9):1387-1394.
14. Dayaakar R, Babu S. Role of HRCT in early diagnosis and management of pulmonary tuberculosis. *Res J Med Sci*. 2024;18:356-360.
15. Bhat T, Yousuf Q, Wani AA, Naik MA, Robbani I, Naqash M. Early detection of smoking induced lung damage in patients with normal pulmonary function tests: evaluation with high resolution computed tomogram (HRCT) chest. *JK Practitioner*. 2020;25.
16. Reddy DP, Kumari VV, Patrudu BMS, Kumar RS, Rao CRB, Dutt A. Role of HRCT in early detection of emphysema in smokers with normal chest radiograph. *Apollo Medicine*. 2025.
17. Ryu JH, Myers JL, Swensen SJ. Bronchiolar disorders. *Am J Respir Crit Care Med*. 2003;168(11):1277-1292.
18. Gülsen A, Uygur B. Psychological features of smokers. *Respir Care*. 2018;63(12):1492-1497.
19. Constantin A, Catrangu MB, Iorga AL. Perspectives in smoking related interstitial lung diseases. *Internal Medicine*. 2024;21(2):111-123.
20. Tsuboshima K, Matoba Y, Wakahara T, Uchida T, Moriyama S. The clinical characteristics and surgical results of smoking-related young pneumothorax. *Gen Thorac Cardiovasc Surg*. 2019;67(12):1070-1074.