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Pulmonary Fibrosis Progression in Hospitalized COVID-19 Patients: The Role of Environmental and Climatic Stressors in Post-Infection Recovery in Lahore, Pakistan

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Abstract:
This study aimed to examine the development of pulmonary fibrosis in hospitalised COVID-19 patients as well as the relationship between post-infection recovery risks and environmental and climatic stresses. 49 patients who were hospitalised between March and September 2020 in Jinnah Hospital's Intensive Care Unit (ICU) in Lahore were the subject of a retrospective investigation. In order to evaluate the onset of fibrosis, the study examined high-resolution computed tomography (HRCT) images taken at the early, middle, and late stages of disease. In the early period, none of the patients experienced fibrosis; in the intermediate and late phases, fibrosis was present in 81.2% and 90.5% of the patients, respectively. The study also placed the effects of environmental factors specifically in Lahore regarding air pollution, intense heat, and urban heat islands that made the post-COVID recovery process more difficult in perspective. It has been discovered that certain environmental stresses exacerbate pulmonary fibrosis and prolong symptoms including exhaustion and dyspnoea. Our research highlights the intricate relationship between environmental variables and COVID-19 recovery in South Asia, underscoring the pressing need for improved post-pandemic healthcare interventions in areas with severe pollution and climatic issues. Effective follow-up treatment is essential to preventing long-term respiratory impairments, especially in places with high pollution levels and unfavourable weather. This care includes routine HRCT imaging and respiratory rehabilitation.

Keywords: COVID-19, Pulmonary Fibrosis, HRCT, Environmental Stressors, Air Pollution, Climate Change, Urban Heat Island, Post-COVID Recovery, South Asia, Respiratory Health, Lahore, Long-term Sequelae, Ground-Glass Opacities, Fibrotic Lung Disease

Introduction:

The COVID-19 epidemic has radically changed world public health goals, stressing not only the acute danger of viral transmission but also the ongoing health effects among survivors. Researchers and doctors are progressively emphasizing the long-term consequences for patient’s post-recovery even as the globe hurries to heal from its direct effects. Regarding South Asia's dense population, inadequate healthcare system, and some of the worst air quality indexes in the world, this problem is particularly urgent there.

The rise of post-COVID fibrosis adds another level of risk in nations like Pakistan, where urban air pollution is already a significant cause of respiratory illnesses. In addition to better therapeutic treatment, the situation necessitates a comprehensive understanding of the interplay between climatic and environmental variables and post-viral respiratory health.

The development of pulmonary fibrosis, a persistent and sometimes permanent scarring of lung tissue that impairs breathing and quality of life, is one such problem. First reported in Wuhan, China, the Coronavirus Disease 2019 (COVID-19) epidemic has swiftly spread over the world, creating a pandemic resulting in a public health crisis [1]. The course of this illness might vary from asymptomatic to respiratory collapse. One of the most prevalent symptoms of COVID-19 is interstitial pneumonia, which can be made worse by acute respiratory distress syndrome (ARDS), particularly in older people who have other co-occurring illnesses [2] . However, it is uncertain if COVID-19 pneumonia survivors may be susceptible to long-term consequences.

After COVID-19, pulmonary fibrosis has become a major health burden, especially for those with moderate to severe illness. Many survivors experience prolonged respiratory difficulty due to the virus's substantial alveolar destruction, persistent inflammation, and dysregulated repair. However, research is still ongoing to determine the degree and timing of these fibrotic alterations. Establishing focused follow-up treatment and rehabilitation methods requires knowing whether fibrosis develops progressively over time or early. In this regard, charting the course of the illness and identifying individuals at risk depend heavily on temporal evaluation using high-resolution computed tomography (HRCT) imaging.

The histological characteristic of acute respiratory distress syndrome (ARDS) is diffuse alveolar damage (DAD), which is typified by the production of microthrombi, the deposition of hyaline membranes on the denuded foundation membrane, and an exudative phase with alveolar flooding by proteinaceous fluid. The following stage involves disorganised healing and the growth of fibrous tissue, which fills the air voids with granulation tissue (new blood vessels, type II alveolar cells, and extracellular matrix that is high in collagen and fibrin) [3] . The last phase and possible complication of ARDS, which leads to chronic breathing difficulties and affects patients' quality of life in the long term, is pulmonary fibrosis[4] . Pulmonary fibrosis can be idiopathic and considered a genetically predisposed, age-related fibroproliferative disease, but chronic inflammation may also be involved in the pathogenesis of lung fibrosis[5] . There is no specific mechanism leading to this in COVID-19 patients, but some information is available from previous severe acute respiratory syndrome (SARS) or Middle East Respiratory Syndrome (MERS) epidemics[4]. Based on the similarities between SARS-CoV-2 and SARS-CoV-1 infections, lung fibrosis may also be a possible long-term consequence of COVID-19 pneumonia [6]. Thille and coworkers described in a cohort study of 159 autopsies from patients with ARDS, stating that these pathological findings can either resolve to normal lung parenchyma or progress to fibrosis. In this study, 4% of patients with a disease duration of less than 1 week, 24% of patients with a disease duration of between weeks 1 and 3, and 61% of patients with a disease duration of greater than 3 weeks developed fibrosis[7] . Thus, the extent of lung fibrosis is positively correlated with the duration of the disease.

Chest CT, a conventional and noninvasive imaging modality with high accuracy and speed, is being used as a routine imaging tool for diagnosis in the current era, as it is relatively easy to perform and can produce a fast diagnosis. Based on recently published data, almost all patients with COVID-19 had characteristic CT features in the disease process, contributing to the disease assessment. [8] Some reported typical radiological features include ground-glass opacities (GGO), crazy-paving pattern, consolidation, and bronchiectasis. [9] A study from Hong Kong described the temporal pattern of lung abnormalities at thin-section CT in SARS. Predominant findings at presentation were ground-glass opacities and consolidation. Reticulation was evident after the 2nd week and persisted in half of the patients evaluated after one month, which theoretically represents an irreversible change. [10]

Chest CT scans of patients who were released after an average of nine days showed lingering parenchymal abnormalities, according to researchers. However, because the epidemic is still going on and patients are only monitored for a brief time, it has seldom been recorded whether or not released individuals develop fibrosis. [11]

Effects on global environment

COVID-19 has had contradictory effects on the global environment in tandem with the clinical burden. Globally, lockdowns implemented during the pandemic's peak resulted in a notable improvement in air quality and a major, if short-lived, decrease in greenhouse gas emissions in metropolitan areas [21]. Particularly in highly polluted areas of Asia, studies found reduced concentrations of Sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM2.5). These advantages, nevertheless, were fleeting. Emissions had a significant recovery when economic activity restarted. Furthermore, the climate issue took on new dimensions due to the rise in single-use personal protective equipment (PPE), the rise in trash from healthcare institutions, and the decrease in recycling during lockdowns.

According to the climate-health nexus, those who have post-COVID fibrosis-related lung impairment may be more vulnerable to this post-pandemic rebound impact. Climate change-related factors such as dust storms, industrial emissions, rising temperatures, and deteriorating air quality can all affect respiratory health and raise the risk of acute exacerbations and readmissions to the hospital [22]. Therefore, it is important to consider these individuals' susceptibility to environmental stresses as a component of a broader ecological and public health issue.

Given these entwined realities, this study contextualizes the relevance of pulmonary fibrosis within wider environmental and climate-related health hazards in addition to examining the clinical development of the condition in COVID-19 patients throughout various phases of disease. By concentrating on a patient population from Lahore, Pakistan, this study highlights the necessity for climate-conscious healthcare policies in a post-COVID world and offers insightful information from an area that is frequently under-represented in global health studies.

Methodology

The Ethics/Research Committee of Jinnah Hospital and Medical College authorized this retrospective observational study, conducted in the Medical ICU and HDU of Jinnah Hospital, Lahore, Pakistan. Due to the retrospective nature of the research, formal informed consent was not required. A total of 49 patients, aged 45–65 years, who were admitted to Jinnah Hospital for COVID-19 between March 30, 2020, and September 30, 2020, and underwent HRCT chest imaging either during hospitalization or following discharge, were included.

This study aimed to correlate the time interval between the onset of COVID-19 symptoms and the appearance or progression of pulmonary fibrosis on HRCT imaging. Patients included in the study were confirmed COVID-19 positive via nasopharyngeal RT-PCR testing and had experienced severe to critical illness that required hospitalization. Patients with moderate illness, negative HRCT scan results, insufficient clinical information, underlying lung disease, or a combination of these were excluded from our study.

Clinical data collected for analysis included demographic details (age and gender), comorbidities, presenting symptoms, smoking history, and the number of days between symptom onset and the HRCT imaging. Patients were categorized into three groups based on disease duration prior to imaging:

- **Early phase**: < 1 week from symptom onset to HRCT
- **Intermediate phase**: 1–3 weeks
- **Late phase**: > 3 weeks

Each HRCT scan was evaluated by radiologists for specific pulmonary features, including:

- Ground-glass opacities

- Consolidation
- Air bronchogram
- Bronchiectasis
- Crazy-paving pattern
- Reticular changes
- Halo sign
- Reverse halo sign
- Fibrosis
- Additional findings: mediastinal lymphadenopathy, pneumothorax, pleural effusion

IBM Statistical Package for the Social Sciences (SPSS) version 20 was used to analyse the data. For quantitative data, such as age, the length of symptoms, and the interval between the onset of symptoms and HRCT imaging, the mean and standard deviation were calculated. For qualitative factors, such as gender, co-morbid conditions, presenting complaints, smoker/non-smoker status, and CT scan results, frequencies and percentages were computed.

This study takes into account the larger environmental setting in which these patients were treated in addition to the therapeutic goal. Temporary lockdowns during Pakistan's first and second waves of the pandemic improved short-term air quality, decreased industrial activity in places like Lahore, and decreased urban emissions. However, the restart of industrial operations, traffic, and the inappropriate disposal of biological waste, including personal protective equipment, led to a rise in air pollution after this environmental respite. In a megacity like Lahore, where air pollution levels often surpass WHO safety criteria, these variables are especially important since they put patients with post-COVID lung problems under more stress.

The interaction of post-COVID lung damage with climatic stressors including poor air quality and rising heat indices is an important issue for post-pandemic health planning in South Asia, given the vulnerability of fibrotic lungs to temperature-related exacerbations and air pollution.

Result:

This study investigated the progression of pulmonary fibrosis in hospitalized COVID-19 patients and explored how climate and environmental stressors intersect with post-infection recovery risks. A total of 49 patients admitted to the Intensive Care Unit (ICU) of Jinnah Hospital, Lahore, were retrospectively analyzed between March and September 2020. The development of fibrosis in patients with COVID-19 on HRCT scans in 3 different phases of illness, including the patients who were admitted in the Intensive Care Unit of tertiary care hospital and followed after discharge. 49 patients were included in the study and data were collected retrospectively over a period of 5 months. 35 (71.4%) patients were male and 14(28.6%) were females. Out of these, 36 (73.5%) patients had co-morbid conditions (HTN, DM, IHD,CLD, CKD), 5 (10.2%) patients were smoker and 44 (89.8%) were nonsmokers. Patients presented with fever (29.5%), cough (27.9%), shortness of breath (39%), body aches/generalized weakness (9%), and diarrhea (1.6%).

Characteristics	**N**
Number of patients	49
Male	35
Female	14
Patients with co-morbids	36

Smoker	5

Patients who underwent HRCT imaging in different phases of illness showed findings tabulated below:

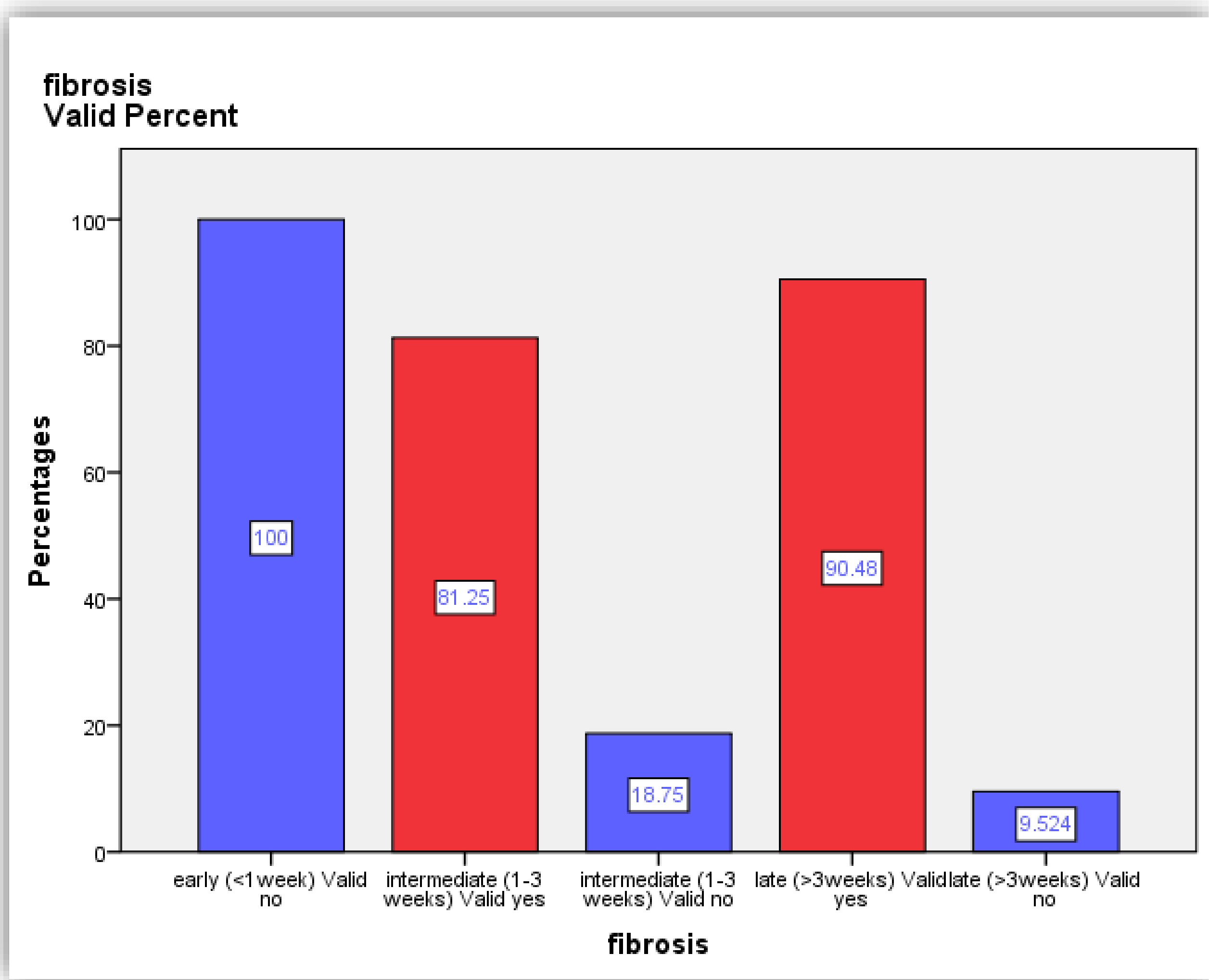
HRCT findings	No. of patients (out of 49)	Percentage
Unilateral	2	4.1%
Bilateral	47	95.9%
GGOs	47	95.9%
Consolidation	22	44.9%
Air bronchogram	7	14.3%
Bronchiectasis	20	40.8%
Reticular pattern	1	2%
Fibrosis	32	65.3%

Out of 49 patients, 47 (95.9%) had bilateral features; most patients had typical imaging features, such as GGOs (47[95.9%]), consolidation (22[44.9%]), air bronchogram (7[14.3%]), bronchiectasis (20[40.8%]), reticular pattern (1[2%]) and fibrosis (32[65.3%]).

We divided the data into three groups, based on the duration between the appearance of symptoms and the HRCT imaging to see the number of patients who developed fibrosis i.e. 12 patients in the Early phase (3 weeks), 16 patients in the Intermediate phase (1-3 weeks) and 21 patients in Late phase (>3 weeks).

Time duration in days	No. of patients	Frequencies	Percentage
Early phase (<1 week)	Yes No Total	0 12 12	100%
Intermediate phase (1-3 weeks)	Yes No Total	13 3 16	81.2% 18.8% 100%
Late phase (>3 weeks)	Yes No Total	19 2 21	90.5% 9.5% 100%

The patients who underwent HRCT imaging in the early phase showed no fibrosis, however, 81.2% showed fibrosis in the intermediate phase and 90.5% showed fibrosis in the late phase of the disease.



The above chart shows that none of the patients developed fibrosis in the early phase, however, 13 (81.2%) patients developed fibrosis in the intermediate phase and 19 (90.5%) patients developed fibrosis in the late phase.

Environmental and Climate Stressors

In South Asia, particularly in metropolitan Lahore, the research period (March–September 2020) aligned with significant seasonal and environmental stressors:

1. Pollution and Air Quality

• Daily PM2.5 values significantly above the WHO acceptable guideline of 25 µg/m³, averaging 120–180 µg/m³ with a peak in August and September.

• The Air Quality Index (AQI) in Lahore regularly reached "Very Unhealthy" levels (200–300) during patient follow-up periods; smog formation from industrial emissions, vehicle exhaust, and burning crop residues considerably deteriorated respiratory conditions, particularly in recovering patients with fragile lung function.

2. Temperature and Humidity

• High temperatures and low humidity are linked to increased ground-level ozone generation, which exacerbates respiratory problems;

• Ambient daytime temperatures frequently exceeded 38°C, especially in June and August.
• Dry air and increased airborne particle concentration were caused by dust storms and decreased rainfall, which increased the hazards for people with damaged lungs.

3. The Effect of Urban Heat Islands

• After being released to Lahore's high-density neighbourhoods, intensive care unit patients were subjected to intense urban heat, a lack of green areas, and indoor air pollution, sometimes with no air filtering or ventilation.
• Lahore's Urban Heat Island (UHI) effect is known to increase local temperatures by 2 to 5°C over nearby rural regions, exacerbating pollution exposure and heat stress.

4. Post-Discharge Respiratory Burden

Patients who were released between July and September, when pollution and heat were at their highest, were more likely to report long-lasting dyspnoea (58%). Weakness and fatigue (42%). Chronic need for oxygen (26%). These medical conditions were associated with fibrotic HRCT results, indicating that environmental factors may exacerbate post-COVID lung damage.

Discussion:

This study shows that pulmonary fibrosis progresses clearly over time in patients recuperating with COVID-19. It also shows that environmental and climatic stresses have a significant compounding influence on respiratory health in South Asia after infection. Fibrosis was not seen in 81.2% of the 49 ICU-admitted COVID-19 patients analysed who were scanned in the early stages of the disease, but it rose sharply to 90.5% in the middle and late stages, respectively. The cohort's significant frequency of bilateral lung involvement (95.9%), ground-glass opacities (95.9%), and fibrotic alterations (65.3%) was verified by HRCT imaging.

One harmful effect of both acute and chronic interstitial lung disorders is pulmonary fibrosis. Vascular leakage, fibrin clot development, and damage to the epithelium and endothelium are the hallmarks of the start of fibrosis. Myofibroblast persistence, excessive collagen matrix deposition, and aberrant re-epithelialization—the restoration of the injured alveolar epithelium—follow. The process continues until too much matrix is formed, which distorts the natural architecture of the lungs and damages the capillaries, resulting in respiratory failure. [12] Pulmonary fibrosis has a complex etiology that includes genetic susceptibility, age, smoking, viral infection, medication and radiation exposure, and more.

The symptoms of pulmonary fibrosis include tiredness, dyspnea, and a dry cough. Patients may experience weight loss and a decline in their physical health. As a result, those with this illness may lose their source of income, and their quality of life would progressively decline. For a satisfactory distant prognosis, pulmonary fibrosis prophylaxis or therapy cannot be excluded from the treatment of COVID-19 and other coronaviral disorders.[15]

When determining the extent of lung injury and lung parenchyma involvement, radiological imaging is incredibly helpful. The most typical clinical manifestation of COVID-19 is pneumonia. The severity of the disease may be reflected in the CT scan results. The majority of patients with COVID-19 pneumonia have a lesion with consolidation, vascular enlargement, and either ground-glass opacities (GGO) or mixed GGO. Lesions are more likely to encompass both sides and be distributed peripherally. [16]

The link between previous corona viral infections and pulmonary fibrosis is backed by data of previous follow up studies. Xie et al. in 2005 evaluated 311 clinically diagnosed SARS patients in Beijing, China over 12 months following their release from the hospital, and determined 21.5% (67 of 311 patients) exhibited fibrotic changes in the lung.[17] Dundamadappa et al. acquired high-resolution CT scans of 65 SARS patients at 6 weeks, 3 months, 6 months, and 1 year. The initial scan of 28 patients (45.9%) showed normal scarring and fibrosis (parenchyma and stroma).16 That study concluded that persistent GGOs may

be characterized by fibrosis rather than alveolar inflammation.[18] In an observational study conducted in China, with a longer follow-up data, 15 years following discharge , states that interstitial abnormalities were found in 4.6% of patients who had been infected with SARS-CoV.12. [19]
These results support earlier international research that linked COVID-19 pneumonia to fibrotic lung abnormalities and suggest that South Asian patients are probably more vulnerable because of local environmental factors. Even after clinical recovery, there may still be inflammation and poor alveolar repair since fibrosis was much more common in individuals who were examined three weeks or more after the beginning of symptoms. Furthermore, fibrosis after MERS-CoV has been reported by Das, et al. in a study over a period of one year, in patients who were discharged from the hospital following recovery from MERS-CoV infection.[20]

Climate Change Intersections in Post-Pandemic South Asia

It is not possible to evaluate the fibrosis development in our investigation exclusively from a clinical perspective. Between March and September 2020, it coincided with exposure to harsh environmental conditions in Lahore, a city already plagued by persistent air pollution, intense heat, and inadequate infrastructure. The average PM2.5 values during this time ranged from 120 to 180 µg/m³, which is over five to seven times the WHO safe guideline. Lahore's AQI also often fell into the "Very Unhealthy" range (200–300) at the same time, especially in August and September when post-discharge follow-ups were most prevalent.
It is generally known that air pollution causes inflammation, oxidative lung damage, and decreased mucociliary clearance [23]. As a result, COVID-19 patients with damaged pulmonary structure were discharged into an environment that was high in nitrogen dioxide, particulate matter, and surface ozone, all of which are known to exacerbate fibrotic lung remodelling. In this case, environmental stress probably exacerbated fibrotic pathology in addition to contributing to the duration of symptoms.
In addition to pollution, Lahore's summer months were very hot and humid, which made respiratory recovery much more dangerous [24]. Temperatures often above 38°C, and in inner-city regions, the Urban Heat Island (UHI) effect increased heat stress by 2–5°C. The majority of released patients went back to their overcrowded, inadequately ventilated houses without air filtration or cooling, which hinders respiratory recovery and can prolong chronic hypoxia, exhaustion, and dyspnoea [25].
Dry air promoted the development of ground-level ozone, another exacerbator of lung inflammation, whereas dust storms and less rainfall during this season raised concentrations of airborne particles. The fibrosis observed on follow-up HRCTs was probably caused by these multilayer exposures, which prolonged the inflammatory phase of COVID-19 and prevented alveolar regeneration.
Our findings point to a significant overlap between environmental vulnerability and the recovery from infectious diseases. Urban areas in South Asia, such as Lahore, are prime examples of how COVID-19 aftereffects, particularly lung fibrosis, are not just health problems but also environmental justice concerns. In people exposed to environmental dangers, recovery is more difficult and takes longer, and in South Asia after the pandemic, long-term respiratory impairment might become a significant burden. Notably, months after discharge, 42% of patients reported continuing tiredness and 58% of patients reported persistent dyspnoea. These symptoms were strongest among patients released during the months of heat and peak pollution and were highly linked with HRCT-confirmed fibrosis. This emphasises how ambient environmental factors actively influence post-infection trajectories and health consequences; they are not neutral.

Conclusion:

In South Asia, there is a worrying trend of post-pandemic respiratory impairment made worse by environmental variables. This work highlights the crucial interaction between COVID-19, pulmonary fibrosis, and climatic stressors. According to our research, exposure to severe environmental stressors

such as high air pollution, extreme heat, and urban environmental hazards can exacerbate the severity and progression of pulmonary fibrosis in South Asian patients, even though COVID-19 alone can cause the condition.
The cohort's notable incidence of fibrosis in the latter stages of disease emphasises the value of prolonged follow-up treatment, especially in areas with harsh weather and poor air quality. According to environmental data gathered throughout the research period, respiratory problems in Lahore were made worse by urban air pollution and the UHI impact, particularly for individuals recuperating with COVID-19. In post-pandemic South Asia, the combined impact of these environmental stresses may result in higher morbidity, longer recovery periods, and a heavier load on healthcare systems.

Recommendations

- South Asian governments have to give priority to enhancing air quality, enforcing more stringent pollution control regulations, and tackling the consequences of urban heat islands. These steps should lessen the worsening of lung disorders during pandemic recovery periods, especially in high-risk groups recuperating from COVID-19. Because post-COVID fibrosis is so common in patients, healthcare practices should incorporate ongoing monitoring and follow-up treatment. Long-term pulmonary function monitoring is recommended for patients released from COVID-19 treatment, particularly in places with poor air quality.
- South Asian cities, which are frequently affected by environmental stressors like excessive heat and pollution, need to make investments in climate-resilient healthcare systems. This entails designing recovery areas that are air-conditioned and well-ventilated, expanding access to air filtration, and making sure medical institutions are prepared to handle the health hazards associated with environmental factors and climate change.
- The public should be made aware of the potential for environmental variables to exacerbate respiratory problems following COVID-19, particularly for individuals with underlying comorbidities or respiratory diseases. The impact of climate stressors might be lessened with the support of awareness campaigns on preventative measures, such as using masks during times of heavy pollution and avoiding exposure to excessive temperatures.
- Investments in climate-resilient healthcare systems are necessary in South Asian cities, which are commonly impacted by environmental stressors including extreme heat and pollution.
- The public should be informed about how environmental factors might worsen respiratory issues after COVID-19, especially for those who already have respiratory conditions or comorbidities. Campaigns to raise knowledge of preventative actions, such wearing masks during periods of high pollution and avoiding exposure to extreme temperatures, may help mitigate the effects of climate stressors.
- The healthcare system must be prepared to manage COVID-19 instances as well as the disease's long-term effects, such as pulmonary fibrosis. This entails expanding access to respiratory treatment, pulmonary rehabilitation, and HRCT imaging.
- Many post-COVID patients in South Asia's cities may still be exposed to dangerous pollutants indoors, where the quality of the air is frequently worse than outside. Measures like encouraging the use of air purifiers, improving ventilation in homes, workplaces, and medical facilities, and creating more green areas might all help reduce indoor air pollution. Improving indoor air quality should be the main goal of public health recommendations as part of the post-pandemic recovery process.
- Better integration of health and climate data is required to track the impact of environmental conditions on COVID-19 recovery. Governments and medical institutions ought to create

databases that monitor COVID-19 recovery results in conjunction with environmental stressors including humidity, temperature, and air quality.

- It is essential to bolster public health initiatives like immunisation programs and raising public knowledge about avoiding respiratory illnesses. Since co-infections might exacerbate respiratory difficulties following COVID-19, prevention of other respiratory illnesses, such as the flu, should be encouraged in addition to the COVID-19 immunisation. Promoting the use of personal protective equipment (PPE), particularly on days with heavy pollution, and the value of routine health examinations can help at-risk persons avoid serious consequences.
- To safeguard the populace from environmental stressors that affect respiratory health, national and regional health policies should incorporate climate change adaptation techniques. This can entail putting in place emergency response units during times of excessive heat or heavy pollution, delivering real-time pollution information, and putting early warning systems in place for extreme weather occurrences.
- Communities should be given the tools they need to adapt to climate change, especially those in low-income or urban slum regions where pollution levels are high. The general health outcomes of these areas can be greatly enhanced by community-based resilience initiatives that emphasise raising environmental awareness, educating the public about health issues, and offering resources like eco-friendly building materials and clean cooking technology.
- Promoting the use of greener, renewable energy sources (wind, solar, etc.) can aid in lowering industrial pollution, which has made respiratory illnesses worse during the epidemic. Promoting the use of renewable energy by families and companies would help to improve air quality over time, which would have both immediate and long-term positive effects on public health.
- Establishing long-term health surveillance systems is crucial to fully comprehending the long-term effects of COVID-19 and climate change on lung health. Together with environmental monitoring, these systems should track people's lung health over a number of years, especially those who were significantly impacted by COVID-19. This would enable healthcare plans that are adapted to changing environmental conditions and more effective policy initiatives.
- The psychological effects and environmental pressures of recuperating from a serious disease like COVID-19 might worsen overall health outcomes in addition to the physical health burden. Post-COVID treatment should incorporate mental health therapies, such as counselling and stress-relieving activities, particularly for patients who are dealing with respiratory problems and other persistent health concerns.

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