Impact of Chronic Lung Disease Using Deep Learning: A Survey

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Abstract. Artificial intelligence has developed in recent years. It is mostly enviable to discover the facility of contemporaneous state-of-the-art techniques and to examine lung nodule features in terms of a large population. Now a days lung plays a major role all over the world in early prevention in disease identification. The latest progress of deep learning sustains the recognition and categorization of medical images of respiratory problems. There are varieties of lung diseases to be analyzed to select the high mortality rate among them. In this paper, we have provided a comprehensive study of several lung ailments, in particular lung cancer, pneumonia, and COVID-19/SARS, Chronic Obstructive Pulmonary Disease. Existing deep learning methodology used to diagnose lung diseases are clearly explained and it will be helpful for the lung disease identify the system.

Keywords: Artificial intelligence · Lung disease · Deep learning

1 Introduction

The living cells and extracellular substances are arranged into tissues, organs, and structures that make up a human's physical substance. Humans have five vital organs that must work properly in order for them to live [1]. The brain, lungs, heart, liver, kidneys are among these organs. The brain serves as a command centre, receiving and transmitting signals to other organs via the neurological system and producing hormones [2]. The human heart is in control of pumping blood around bodies [3]. The function of the kidneys is to eliminate waste and excess fluid from circulation [4]. The liver has to detoxify toxic substances from the body [5]. The lungs are in control of extracting oxygen from the air while breathing and transporting it to our bloodstream and delivered to our cells and Carbon dioxide is also removed by the lungs [6]. A coronavirus illness has begun to spread over the world, posing a serious threat to public health and the illness has been categorized as a pandemic, by March 2021, there were 118.7 million individuals on the globe, with 2.6 million fatalities confirmed [7]. As per the World Health Organization's most early stats, more than two hundred sixty-seven million individuals had been infected as of December 10th, 2021, with close to 5,285,888 fatalities [8].

Published by Springer Nature Switzerland AG 2022
E. J. Neuhold et al. (Eds.): ICCCSP 2022, IFIP AICT 651, pp. 46–59, 2022.
https://doi.org/10.1007/978-3-031-11633-9_5

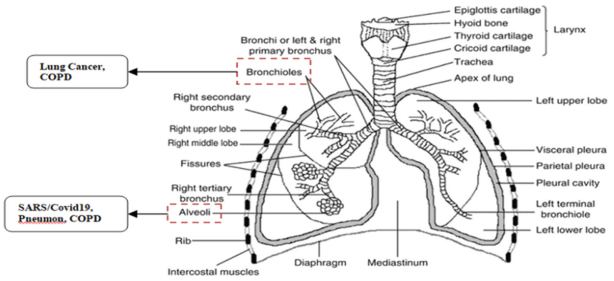

Fig. 1. Lung respiratory system anatomy [source: https://pharmacyimages.blogspot.com]

The basic tasks of the lungs are to inhale oxygen and expel carbon dioxide. On either side of the chest, the lungs are set of two soft air-filled organs thorax. The Lungs inhale, air enters through the nose and travels by way of the trachea (windpipe) [9]. Alveoli are small air sacs located near the end of the bronchioles. During breathing diaphragm muscle that moves up and down in the chest, forcing air in and out of the lung [10]. The basic tasks of the lungs are to take in oxygen and expel carbon dioxide. Lung Structure is shown in Fig. 1 Lung Respiratory System Anatomy**.**

2 Review of Lung Disease

Lung diseases generally called respiratory diseases are disorders that affect the lungs, bronchi, and other elements of the respiratory system. Chronic Obstructive Pulmonary Disease (COPD) is a chronic illness that makes it difficult to breathe and a symptom of this disease was having trouble blowing air out from the lung [11]. It has two types of COPD, Emphysema and chronic bronchitis which are both caused by smoking; lung alveoli (air sacs) get damaged [11]. Asthma indicia of the lung muscles tighten and irritability, Airway blockage, Inflammation are illuminated [12]. Acute bronchitis causes nagging cough and mucus and the manifestation of this disease was infected of the lung's large airways (bronchi) [13]. Recognition by checking the oxygen levels in the blood, lung function test, Blood tests, chest X-ray is expounded [14]. Pneumonia causes difficulty to get enough oxygen into the blood while breathing. A sign of this disease was streptococcus pneumonia (bacteria) [15]. Diagnosis along with CT scan, X-ray of the chest, arterial blood gas test, sputum test, blood testing and pulse oximetry test is illustrated [16]. Pulmonary fibrosis disease causes shortness of breath [17]. Different types of crucial diseases that affect the lung are shown in Fig. 2 Lung Disease Infection Rate.

Sarcoidosis disease causes inflammation in small regions of the lung. It is a sign of this disease was granulomas are abnormal lumps or nodules made up of inflammatory tissues. Blood tests, pulmonary function tests, HRCT scans, and upper body X-rays are all used to identify the condition discussed [18]. A thin membrane that borders the interior of the chest wall and the surface of the lungs is known as the pleura on X-rays, pleural effusions look white. Chest X-ray was used to make the identification [19]. Recognition by BMI Calculation, Skin fold callipers physical test is described [20].

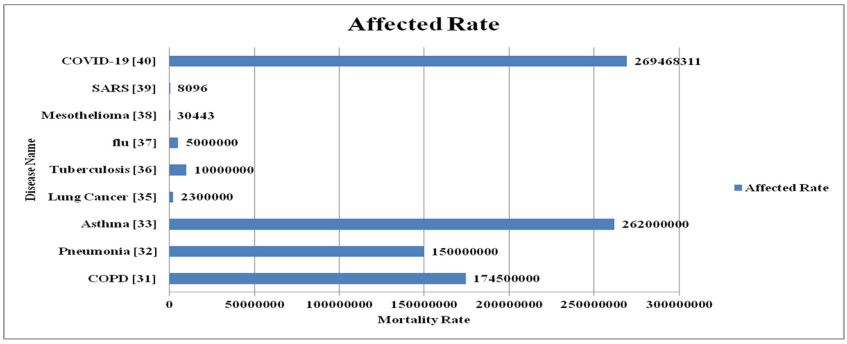

Fig. 2. Lung disease infection rate

Blood tests, chest film, CAT scans, and electrocardiograms are utilized to make recognition are illuminated [21]. Bronchiectasis lung disease causes coughing with large amounts of mucus. Blood tests, Roentgen rays test, pulmonary function tests and CAT scans and are used to make recognition is specified [22]. It symptom of this disease was cysts form throughout the lungs (gas). Blood tests, chest film scans, bronchoscopy test, pulmonary function tests, and thoracoscopy are used to make detection [23].Recognition by way of blood tests, DNA test, and sweat test is expounded [24]. Blood tests, chest X-rays, CT scans, and pulmonary function tests are used to make identification and it is amply elucidated [25]. Lung cancer disease causes cancer may affect almost any part of the lung. It looks like soft, pinkish grey walls of the bronchi or bronchioles (lung airways) or alveoli were the first to show signs of this illness (air sacs). Spiral or helical low-dose CT scanning is used to diagnose by early stages of lung cancer are illuminated [26]. Identification along with Blood tests, chest X-ray, Skin test, Acid-fast bacillus (AFB) tests [27]. Acute respiratory distress syndrome (ARDS), which causes breathing issues. The symptom of this disease was Fluid building up in the lung, limiting oxygen from reaching organs [28]. The symptom of this disease was fungus Coccidioides infection when inhaled. Recognition by way of Blood tests, chest X-ray, CT scan, a skin test is illustrated [29].

Histoplasmosis disease, which causes cough. The symptom of this disease was breathing in histoplasma capsulatum, a soil-borne fungus and a case of the flu disease [30]. Blood tests, CAT scans test, pulmonary function tests, chest roentgen rays test and lung biopsies are all used to make a recognition were explained [31]. Quick antigen testing, immune fluorescence tests, and rapid molecular assays reverse transcription-polymerase chain reaction test are all used to identify flu is elucidated [32].

These are the lung diseases affected. Lung Disease Death Rate is shown in Fig. 3 Perceive COVID-19, COPD, Pneumonia, Lung Cancer because of a higher fatality rate.

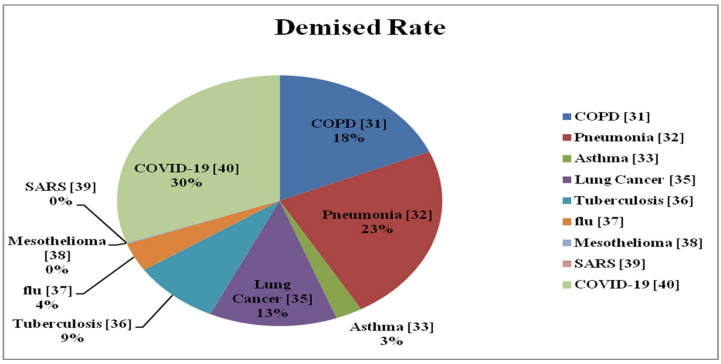

Fig. 3. Lung disease demised rate

Mesothelioma is a type of cancer cell, which invades and damages nearby tissues. Blood tests, fluid and tissue sample testing, chest X-ray, paracentesis, CT scan, and thoracentesis are all used to make a spotting tumor cell and it is clearly exemplified [33]. Pertussis disease causes coughing. It's a contagious infection of the bronchi (airways). Diagnosis by way of Blood tests, chest X-ray is expounded [34]. Pulmonary hypertension disease caused by High blood pressure and the indication of this illness was high blood pressure in the arteries [35]. Blood tests, CAT scans, upper body X-rays scan, and pulmonary function tests are used to make recognition was discussed [36].

Severe acute respiratory syndrome (SARS) disease causes a virus that infects body cells and uses them to replicate itself [28]. The SARS-CoV-2/COVID-19 disease can cause pneumonia, both lungs are affected and fill with fluid, making breathing difficult [37]. SARS-CoV-2/COVID-19 disease's symptoms immediately affect the lungs and destroy the alveoli (tiny air sacs). Pneumothorax disease, which causes coughing. Diagnosis by way of EKG to assess the heart functioning, arterial blood gas and pulse oximetry test to detect oxygen in the blood is illustrated [38].

3 Lung Disease Analysis

Due to Lung diseases bronchioles, alveoli are affected due to region, drug history, working environment, genetic predisposition and age. Let us discuss major causes of diseases such as Lung Cancer, Covid-19/SARS, Pneumonia, and Chronic Obstructive Pulmonary Disease. Lung Cancer detection methods and merits & demerits are illustrated in Sect. 3.1. Covid-19/SARS analyses are given in Sect. 3.2. Pneumonia analysis is given in Sect. 3.3. Chronic Obstructive Pulmonary Disease analysis is given in Sect. 3.4.

3.1 Lung Cancer

Lung cancer cells grow out of control and form a tumor, damaging healthy lung tissue in the meantime [39]. Sudden shortness of breath, continual chest pain, and vision issues, to mention a few symptoms, can occur at any time [40]. Stages first (single tumor) and

second (spread to lymph nodes) are treated with surgery. Stages third (spread chest wall, lymph nodes) and Chemotherapy and/or radiation are used to treat stage four. The final fifth stage (Spread beyond the chest) is treated with Chemotherapy or palliative care. Lung cancer has two different major types [41]. Lung cancer types are shown in Fig. 4. [Source: https://www.cancer.org/].

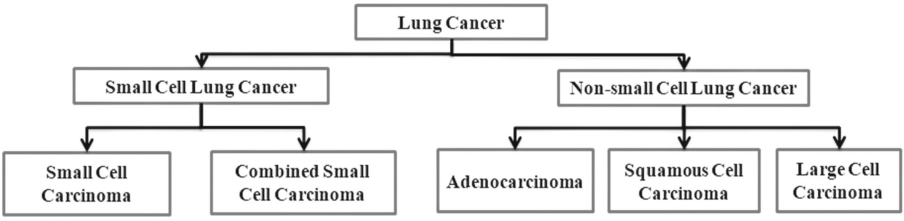

Fig. 4. Lung cancer types

- **Small cell lung cancer**
  It is also known as Oat cell lung cancer. It is estimated that 10% to 15% of all lung cancers are caused by this SCLC. Nearly 70% of those with SCLC will already have cancer that has spread by the time they are diagnosed. It can be treated with chemotherapy and radiation therapy [41].
  Small cell carcinoma
  It is most commonly found in the bronchi (breathing tubes) and spreads rapidly throughout the body, forming huge tumor and spreading metastasizing.
  Combined small cell carcinoma
  It is a combination of small cell and squamous cell carcinomas, with or without adenocarcinoma.
- **Non Small cell lung cancer**
  It is estimated that 80% to 85% of all lung cancers are caused by this NSCLC [42].
  Adenocarcinoma
  It's more typically seen in the outer regions of the lung. It's also more likely to be discovered before proceeding it spreads.
  Squamous cell carcinoma
  Squamous cells are flatter cells that line around the interior of the lung airways. It is generally located near an air tube in the middle of the lung (bronchus). Frequently seen near a primary airway bronchus in the middle area of the lungs and it is connected to a history of smoking.
  Large cell (undifferentiated) carcinoma
  It can develop in any region of the lungs. It has a proclivity for spreading and growing rapidly, increasing the difficulty of treatment.

Apart from common Lung cancer, there are some rare categories which are Pancoast Cancer, Carcinoid cancer. Table 1 is shown below discussing the lung cancer identification and it is methods with data set label and Performance Measure.

Table 1. Lung Cancer with their working methods

Author/Year	Methodology/Performance	Limitation
Surendar P, 2021 [40]	Classification using DNN-ASCCS Neural-Network with accuracy 99.17%	Difficulty in the discovery of early lung tumor classification
Ying Su, 2020 [43]	R-CNN algorithm can identify lung nodules with accuracy 91.2%	Lack of accuracy
Anushikha Singh, 2021 [44]	Deep neural network techniques are used for classification with accuracy 98%, specificity 99.71%, jaccard index 95.21%, dice coefficient restnet18 95.28%	New investigation is difficult
Stojan Trajanovski, 2021 [45]	DNN algorithm is used to assess cancer risk with Sensitivity-93%, specificity -81%, Area Under the Curve of 94%	Smaller database is only allowed
M. Ibrahim, 2021 [7]	Diagnosed using a VGG19 + CNN deep learning model with Accuracy-98.05%, Recall-98.05%,Precision-98.43%, Specificity-99.5%	Only pre-trained model is implemented

3.2 Covid-19/SARS

It starts from the Lung area only. Affects only lungs area damages the alveoli (tiny air sacs). It affected the Lungs mostly. The virus causes damage to the alveolus and capillary walls and linings. As a result of the damaged lung, plasma protein debris gathers on the alveolus wall and thickens the lining. Furthermore, a lack of oxygen reaching the body's interior organs generates a deficit and hinders organ function [46]. The air sacs are damaged, a fluid inflow ensues and it is mostly composed of inflammatory cells and protein, and this fluid build-up triggers pneumonia [47]. Table 2 shows Covid-19/SARS studies and their algorithm techniques.

Table 2. Covid-19/SARS with their working methods

Author/Year	Methodology/Performance	Limitation
Shayan Hassantaba, 2020 [48]	COVID-19 is evaluated using a ResNet with SVM model with 95.38% Accuracy, 97.29% Sensitivity	Smaller dataset is tried
Seda Arslan Tuncer, 2021 [49]	Scat-NET architecture with SVM Classification Layer with accuracy 92.4%	It requires more precision
Kabid Hassan Shibly, 2020 [50]	Faster R–CNN with Accuracy-97.36%, Specificity-95.48%, Sensitivity-97.65%	Robustness is less
Md. Zabirul Islam, 2020 [51]	Convolutional Neural Network model with Accuracy-99.4%, Specificity 99.2%, Sensitivity-99.3%	Algorithm complexity is high

3.3 Pneumonia

Pneumonia is a lung illness that affects the airways. It leads to inflammation of the alveoli in one or both lungs and alveoli filled with fluid or purulent substance. Different kinds of pneumonia [52] are shown in Fig. 5 [source: https://www.healthline.com/].

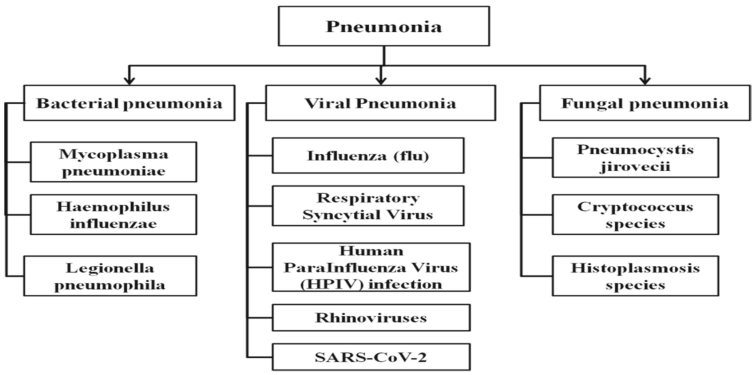

Fig. 5. Pneumonia types

Pneumonia can be categorized according to the part of the lungs it affects.

- **Bacterial pneumonia**
  Streptococcus pneumonia is the most prevalent cause of bacterial pneumonia.
  Mycoplasma pneumonia
  Mycoplasma pneumonia is a highly infectious respiratory illness spread via contact with respiratory secretions.
  Haemophilus influenza
  Haemophilus influenza is a Gram-negative coccobacillus that infects children's upper respiratory tracts through nasal secretions.
  Legionella pneumophila
  Legionnaires' disease is a particularly severe type of pneumonia, It is a lung infection.
- **Viral pneumonia**
  Pneumonia is frequently caused by respiratory viruses.
  Influenza (flu)
  Influenza is an infection that affects the nasal, windpipe, and lungs, among other parts of the respiratory system.
  Respiratory Syncytial Virus
  Respiratory Syncytial Virus is among the most common viruses that cause lung and airway infections in infants and small children.
  Human Parainfluenza Virus (HPIV)
  Babies, small children, the elderly, and anyone with weakened immune systems are all at risk and the most prevalent victims of the Human Parainfluenza Virus, however, anybody can become infected.
  Rhinoviruses

The common cold is an upper respiratory illness. Inhaling virus particles from an affected people's cough, sneeze, talk, or unwanted particles from when they wipe their nose spreads the common cold.

SARS-CoV-2

The SARS-CoV-2 virus can infect both the lungs and fluid fills them making breathing difficult. The symptoms of this illness strike the lungs first, destroying the alveoli (tiny air sacs).

- **Fungal pneumonia**

  Fungal pneumonia can be caused by fungi found in soil or bird droppings. Immune-compromised individuals are more susceptible to pneumonia in the long run.

  Pneumocystis jirovecii

  Pneumocystis Carinii Pneumonia (PCP), is a kind of pneumonia caused by Pneumocystis Carinii, also known as Pneumocystis jirovecii.

  Cryptococcus species

  Cryptococcosis is an infectious illness caused by pathogenic encapsulated yeasts of the genus Cryptococcus; it can appear in a variety of ways.

  Histoplasmosis species

  Histoplasmosis is a bacterial illness that affects the lungs. Inhaling Histoplasma capsulatum fungus spores causes it. Apart from common pneumonia, there are some rare categories which are bronchi pneumonia, lobar pneumonia. Table 3 describes the methodology used in Pneumonia disease analysis.

Table 3. Pneumonia with their working methods

Author/Year	Methodology/Performance	Limitation
Adhiyaman Manickam, 2021 [16]	Segmented and classified using the U-Net architecture with ResNet50-Accuracy-93.06%, InceptionV3-Accuracy-92.97% and InceptionResNetV2-Accuracy-92.40%	It is validated with pre trained model
Helena Liz, 2021 [53]	Combines XAI Techniques and CNN Model with Area Under the Curve (AUC) = 0.92	It is incorporated into a particular dataset

3.4 Chronic Obstructive Pulmonary Disease (COPD)

Chronic Obstructive Pulmonary Disease (COPD) is a protracted lung illness that makes breathing difficult [54]. Emphysema and chronic bronchitis are the two most common conditions that cause COPD and two issues are generally present at the same time in COPD patients [55], and their severity varies is shown in Fig. 6 [Source: https://www.medicalnewstoday.com/articles/copd-types] and Table 4 summarizes the techniques used in studies of COPD.

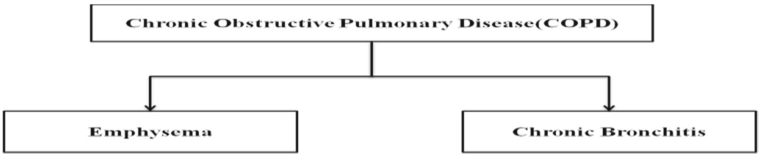

Fig. 6. Chronic obstructive pulmonary disease

Emphysema is a lung condition in toxic tobacco that damages the alveoli at the end of the lung bronchioles tiniest air channels. Chronic bronchitis is characterized by a daily cough as well as mucous production (sputum). Table 4 Represent the Chronic Obstructive Pulmonary Disease (COPD) recognition.

Table 4. COPD with their working method

Author/Year	Methodology/Performance	Limitation
Gokhan Altanc, 2020 [54]	Deep Learning techniques with Hilbert-Huang with Accuracy 93.67%, Sensitivity 91%, Specificity 96.33%	Complexity is high
Ran DU, 2020 [55]	Multi-view CNN based Classification with Accuracy 88.6%	Accuracy is less

The high lung disease demise rate is shown in Fig. 7 four major diseases that affect the lungs most in a current scenario. Commonly affected regions are the lung area and It is similar symptoms are Breathing Issues, Persistent cough.

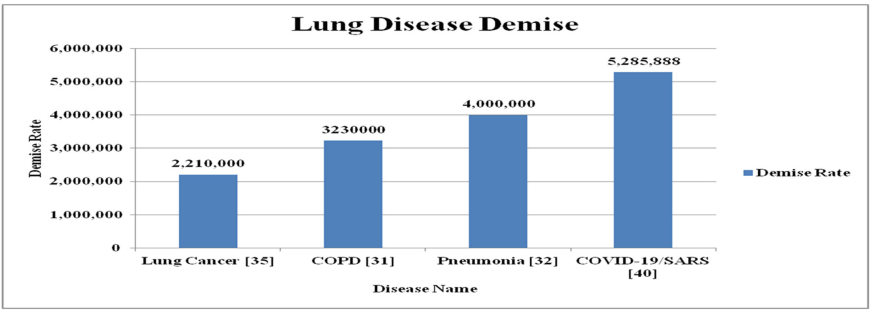

Fig. 7. Lung disease demise rate

4 Summary

Based on the literature carryout in the above sections four major diseases lung cancer, COPD, Pneumonia, COVID-19/SARS has been identified that cause major impact on lung. Research will be extended to improve the consequences faced due to above diseases. Here few dataset also represented in Table 5 to validate the disease in future.

Table 5. Dataset for lung diseases

Disease	Dataset
Lung Cancer	The Lung Image Database Consortium and Image Database Resource Initiative (LIDCIDRI) [40, 43]
	Japanese Society of Radiological Technology (JSRT) dataset, MC dataset, Shenzhen dataset, Indian hospital private dataset [44]
	National Lung Screening Trial (NLST), Lahey Hospital and Medical Center (LHMC), Kaggle competition data, the University of Chicago data [45]
	COVID19-GIT hub public data collection, the Radiological Society of North America (RSNA), the Italian Society of Medical and Interventional Radiology (SIRM), and Radiopaedia [7]
COVID-19/SARS	Github public access dataset: Name: Fig. 1 COVID-19 Chest X-ray Dataset Initiative [48]
	Private data Elazig City Hospital between 01.10.2020 and 01.01.2021 [49]
	COVID chest X-Ray dataset curated by Dr. Joseph Cohen, a postdoctoral fellow at the University of Montreal, RSNA pneumonia detection challenge Kaggle dataset [50]
	GitHub Public Dataset, Radiopaedia, The Cancer Imaging Archive (TCIA), and the Italian Society of Radiology (SIRM) [51]
Pneumonia	MIMIC-CXR dataset (X-ray images), LUNA16 and LIDC-IDRI datasets (CT images) [16]
	X-ray pediatric-pneumonia (XrPP) dataset provided by BenGurion University (Israel) [53]
COPD	RespiratoryDatabase@TR is a multi-media respiratory database and provides an equipped potentiality of analyzing COPD for digital signal processing [54]
	Central Hospital Affiliated to Shenyang Medical College during the period of 2016–2020 [55]

5 Conclusion

Lung diseases are one of the most widespread therapeutic situations in the world. Respiratory diseases are the primary source of disease and illness in the world. Sixty five

million people suffer from lung diseases and three million expire from it each year, making it the third foremost reason for demise worldwide. This study shows the extensive survey of prospective lung diseases and the detailed view of lung cancer, COPD, Pneumonia, COVID-19/SARS. The lung diseases listed above cannot be completely healed but recognition at an early stage can assist professionals in treating it effectively and inhibit the patient's prominent lung disease. Further research is required into an impending snag for lung disease and it is useful for medical diagnosis.

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