**Classification of Lung Cancer by using Pathological Images**

Report Submitted in Partial Fulfilment of the requirements for the Degree of

**Bachelor of Technology**

in

**Computer Science Enginerring**

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(State Private University through State Legislature Act No 10 of 2013 of Uttarakhand approved by UGC)

**January-May 2025**

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# ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our supervisor**, Dr. Priya Dangwal**, for their invaluable guidance and support throughout this thesis project. Their expertise in the field of artificial intelligence and language processing was instrumental in shaping the direction of our research and ensuring the quality of our work. We are particularly grateful for supervisor's specific contribution, i.e., their insightful feedback during brainstorming sessions, their encouragement to pursue a specific research direction, or their help in troubleshooting technical challenges.

We are grateful for the opportunity to have worked on this project and for the support we received from so many people. Finally, we would like to thank our families and friends for their unwavering support and understanding during this challenging but rewarding endeavour. Their patience and encouragement were essential in helping us persevere through the long nights and demanding deadlines

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\*\*List of Symbols and Abbreviations\*\*:

- NSCLC: Non-Small Cell Lung Cancer

- SCLC: Small Cell Lung Cancer

- COPD: Chronic Obstructive Pulmonary Disease

- EGFR: Epidermal Growth Factor Receptor

**Abstract**

Lung cancer remains one of the leading causes of cancer-related deaths worldwide, highlighting the urgent need for accurate and early diagnostic tools. Histopathological image analysis plays a critical role in the diagnosis and classification of lung cancer subtypes. This study presents a computational approach to automate the classification of lung cancer using digital pathological images. By leveraging deep learning techniques, specifically convolutional neural networks (CNNs), we develop a model capable of distinguishing between major lung cancer subtypes, such as adenocarcinoma, squamous cell carcinoma, and benign tissues.

The proposed method involves preprocessing of high-resolution histopathology images, data augmentation to improve model generalization, and training of a CNN-based classifier using a publicly available dataset. The performance of the model is evaluated using metrics such as accuracy, precision, recall, and F1-score. Experimental results demonstrate that the model achieves high classification accuracy, indicating its potential as a reliable diagnostic aid for pathologists. This work contributes to the growing field of computer-aided diagnosis and highlights the potential of artificial intelligence in enhancing the efficiency and accuracy of lung cancer detection.

\*\*Identification of Lung Cancer through Classification of Pathological Images: \*\*

Lung cancer, a leading global cause of cancer-related deaths, originates in the lungs and is primarily driven by smoking, though non-smokers are also at risk from environmental factors like air pollution, occupational exposures, and genetic predisposition. This report comprehensively examines lung cancer, covering its types—non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC)—causes, risk factors, genetic influences, occupational hazards, symptoms, and the critical role of early diagnosis. NSCLC, the most common type, grows slower and is more treatable if detected early, while SCLC is aggressive and often diagnosed late. Key risk factors include smoking, secondhand smoke, air pollution, radon, and workplace carcinogens like asbestos and diesel exhaust. Symptoms range from subtle early signs like a persistent cough to severe late-stage manifestations such as weight loss and bone pain. Early diagnosis through screening significantly improves survival rates, emphasizing the need for awareness, better screening access, and preventive measures to reduce the global burden of lung cancer.

**\*\*Chapter 1: Introduction**\*\*

Lung cancer is a type of cancer that starts in the lungs, which are the organs responsible for helping us breathe by taking in oxygen and releasing carbon dioxide. It's one of the most common and serious types of cancer worldwide. There are two main types of lung cancer: non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC). NSCLC is the more common type, while SCLC tends to grow and spread faster. Lung cancer usually begins in the lining of the airways and can spread to other parts of the body over time. This happens when the cells in the lungs start growing abnormally and uncontrollably. The exact cause of this is often unclear, but smoking is the most significant risk factor. However, people who don’t smoke can also get lung cancer, and environmental factors like air pollution or a family history of the disease can play a role. Symptoms of lung cancer can be subtle at first, which is why it's often diagnosed at a later stage. Common signs to watch for include a persistent cough, chest pain, shortness of breath, coughing up blood, and feeling very tired. Treatment for lung cancer depends on the type and stage. Options include surgery, radiation therapy, chemotherapy, targeted therapy, and immunotherapy. Early detection through screening can help improve the chances of successful treatment, but lung cancer is often not found until it has spread.

Lung cancer is a major global concern because it affects millions of people around the world and is one of the leading causes of cancer-related deaths. The main reason it’s such a widespread issue is that it can happen to anyone, anywhere, and it is often diagnosed too late for effective treatment. This makes it a serious health challenge for both individuals and healthcare systems. Smoking is the leading cause of lung cancer, and for many years, smoking was common in many parts of the world. Though smoking rates have decreased in some countries, the effects of smoking still linger. It can take decades for lung cancer to develop after years of smoking, so many people who smoked in the past are still at risk today. But even non-smokers can get lung cancer, as exposure to things like air pollution, secondhand smoke, or harmful chemicals can also increase the risk. Lung cancer is also particularly dangerous because it often doesn't show symptoms until it’s too late. Early signs, like a cough or feeling tired, are easy to ignore. By the time people are diagnosed, the cancer may have already spread to other parts of the body, making it harder to treat. This late-stage diagnosis is why survival rates are lower compared to other types of cancer. Another reason lung cancer is a global concern is that it puts a significant effect on healthcare systems. Treating lung cancer is expensive, and many countries, especially low- and middle-income ones, struggle to provide the necessary care for those affected. Efforts to reduce smoking, improve air quality, and raise awareness about early detection can help reduce the global impact of lung cancer. Until then, it remains a top priority in public health worldwide.

**\*\*Chapter 2: Related Work/Literature Survey**\*\*

Lung cancer has been extensively studied due to its global prevalence. Research identifies smoking as the leading cause, responsible for about 85% of cases, with secondhand smoke, air pollution, and occupational exposures like asbestos also contributing significantly. Studies highlight genetic predisposition as a factor, with mutations in genes like TP53 increasing susceptibility. The American Cancer Society notes that lung cancer often presents late-stage symptoms, contributing to lower survival rates compared to other cancers. Recent advancements in targeted therapies, such as EGFR inhibitors, show promise in treating specific genetic mutations in NSCLC. Screening programs using low-dose CT scans have been shown to reduce mortality by detecting cancer early in high-risk populations. Additionally, research emphasizes the role of occupational exposures, such as asbestos and diesel exhaust, in increasing lung cancer risk, particularly in industries like construction and mining. Public health initiatives focusing on smoking cessation, air quality improvement, and workplace safety are critical to reducing lung cancer incidence.

**\*\*Chapter 3: Causes and Risk Factors of Lung Cancer\*\***

Lung cancer is a serious and often life-threatening disease that can be caused by a variety of factors. Understanding the causes and risk factors of lung cancer is important because it can help us prevent the disease, catch it early, and find ways to reduce the chances of developing it.

**3.1. \*\*Smoking: The Biggest Cause\*\***

The leading cause of lung cancer by far is smoking. Cigarette smoke contains thousands of harmful chemicals that can damage the cells in your lungs over time. Smoking is responsible for about 85% of lung cancer cases. The more someone smokes, and the longer they’ve been smoking, the higher their risk of developing lung cancer. But it’s not just people who smoke regularly who are at risk—occasional smoking can still cause harm.

**3.2 \*\*Second-hand Smoke\*\***

Even if you don’t smoke yourself, second-hand smoke can also put you at risk for lung cancer. This is the smoke that comes from the burning end of a cigarette or from someone else’s puff. It contains the same harmful chemicals as the smoke a smoker inhales, and people who are regularly exposed to second-hand smoke are at a higher risk of developing lung cancer. This is why it's important to avoid environments where people are smoking, like enclosed spaces or homes where smoking is common.

**3.3 \*\*Air Pollution\*\***

Air pollution is another significant risk factor for lung cancer. Living in areas with high levels of air pollution, such as big cities or areas with lots of industrial activity, increases your chances of developing lung cancer. Pollutants like car exhaust, factory emissions, and other chemicals in the air can irritate and damage the lungs over time. People who spend a lot of time in polluted environments, like truck drivers or workers in factories, may be at higher risk.

**3.4 \*\*Radon Exposure\*\***

Radon is a naturally occurring radioactive gas that is released from the ground. It can build up in homes, especially in basements or poorly ventilated areas. Long-term exposure to radon can damage the lungs and lead to lung cancer. Radon is the second leading cause of lung cancer in the U.S., after smoking. The good news is that it’s possible to test for radon in your home and reduce your exposure if needed.

**3.5\*\*Occupational Exposure to Carcinogens\*\***

Certain jobs or work environments can increase the risk of lung cancer because of exposure to harmful chemicals. Asbestos, a material once used in construction, is one of the most dangerous substances. People who worked in construction, shipbuilding, or manufacturing, especially before the dangers of asbestos were widely known, are at a higher risk. Other workplace hazards, such as exposure to certain chemicals or diesel exhaust, can also increase the likelihood of developing lung cancer.

**3.6\*\*Occupational Exposures\*\***

Occupational exposure refers to the harmful substances or environments people may come into contact with while at work. These exposures can increase the risk of developing serious health conditions like lung cancer. Many jobs carry a higher risk for lung cancer because workers are exposed to toxic chemicals, dust, and fumes over long periods of time. Let’s explore some of the most common occupational exposures that contribute to lung cancer in a more understandable way.

**3.7 \*\*Asbestos\*\***

Asbestos is one of the most dangerous substances for lung health. It was once widely used in construction and industries like shipbuilding and manufacturing because it was heat-resistant. But when asbestos is disturbed, tiny fibers can get into the air and be inhaled. These fibers can cause serious damage to the lungs over time and significantly increase the risk of lung cancer, especially mesothelioma, a rare form of cancer linked directly to asbestos. People who worked in construction, shipyards, or even in older buildings where asbestos was used are at risk. The harmful effects of asbestos exposure can last for many years, often appearing decades after someone has stopped working with it.

**3.8\*\*Diesel Exhaust\*\***

Diesel exhaust is another common workplace exposure that can lead to lung cancer. Diesel engines are found in trucks, buses, trains, and construction equipment. Workers who spend long hours around diesel engines, such as truck drivers, construction workers, and railroad employees, are at risk of inhaling harmful fumes that contain carcinogens like benzene and formaldehyde. Studies have shown that people regularly exposed to diesel exhaust have a higher risk of lung cancer. The risk is even greater if the person is a smoker, as smoking and diesel exposure together can have a compounding effect on lung health.

**3.9\*\*Silica Dust\*\***

Silica dust, which is produced when cutting, grinding, or drilling materials like concrete, stone, or glass, is another significant occupational hazard. People who work in industries such as mining, construction, and stone cutting are at risk of inhaling tiny silica particles. Over time, inhaling silica dust can cause a condition called silicosis, a form of lung scarring that also increases the risk of lung cancer. Workers exposed to silica dust are up to three times more likely to develop lung cancer compared to the general population. The risk is especially high in those with prolonged exposure and those who also smoke.

**- \*\*Formaldehyde\*\***

Formaldehyde is a chemical used in a variety of industries, including in the manufacture of building materials, textiles, and household products. It's also used in laboratories and medical settings as a disinfectant or preservative. People who work in industries like funeral homes, textile factories, or laboratories may be exposed to formaldehyde. Formaldehyde is classified as a human carcinogen, and studies show that long-term exposure to high levels of this chemical can increase the risk of lung cancer. Workers in high-exposure jobs may be at an even greater risk, especially if they also smoke.

**- \*\*Chromium Compounds\*\***

Chromium is used in various industrial processes, including metal plating, welding, and in the production of certain chemicals. The form of chromium known as chromium VI (hexavalent chromium) is highly toxic and a known carcinogen. Workers exposed to chromium VI, such as those in the metal industry, welders, and painters, face an increased risk of lung cancer. When inhaled, chromium VI can cause significant damage to the lungs, leading to chronic respiratory problems and cancer. Studies show that workers exposed to chromium VI are several times more likely to develop lung cancer compared to the general population.

**- \*\*Coal Dust\*\***

Coal miners have long been known to be at risk for lung diseases, especially black lung disease (pneumoconiosis), which is caused by inhaling coal dust. Over time, the particles from coal dust can cause scarring and inflammation in the lungs, which increases the likelihood of lung cancer. While coal mining itself is a primary risk, people who work in related industries, like coal transportation and power plants that burn coal, may also face increased risks due to prolonged exposure to coal dust. The risk of lung cancer in coal workers is further heightened for those who smoke.

**- \*\*Other Chemical Exposures\*\***

There are many other chemicals in industrial settings that can increase the risk of lung cancer, including arsenic, benzene, cadmium, and vinyl chloride. Workers in industries such as electronics manufacturing, chemical production, and metalworking may be exposed to these harmful substances. Long-term exposure to these chemicals can lead to lung cancer, among other serious health problems.

**- \*\*Protective Measures and Prevention\*\***

Fortunately, many workplaces have become safer over the years due to stricter regulations and safety measures. Employers are now required to provide protective equipment, such as respirators, and improve ventilation systems to reduce exposure to harmful substances. Additionally, workers are encouraged to undergo regular health screenings to catch lung cancer or other diseases early, especially in high-risk jobs. In some industries, exposure to hazardous substances is unavoidable, but safety practices and preventive measures can help reduce the risks. Ensuring that workers are educated about the dangers they face and providing proper protective gear are essential steps in minimizing the risk of occupational lung cancer.

**6. \*\*Family History and Genetics\*\***

Sometimes, genetics plays a role in lung cancer. If your parents or close relatives have had lung cancer, your risk might be higher. Certain genetic mutations can make people more vulnerable to lung cancer, especially if they are also exposed to other risk factors like smoking or pollution. While genetics cannot be changed, knowing your family history can help you make informed choices about screening and prevention.

**\*\*Genetic Predisposition\*\***

Genetic predisposition to lung cancer refers to the idea that certain people may be more likely to develop the disease due to their genes—basically, the instructions passed down from their parents that shape how their bodies work. While environmental factors like smoking and pollution are the main contributors to lung cancer, genetics can play a significant role in determining who is more susceptible to the disease, even when these environmental risks are present. Let’s break this down in a way that makes sense.

**- \*\*Understanding Genetics and Lung Cancer\*\***

Our DNA contains all the information needed to build and maintain our bodies. Sometimes, mistakes, or mutations, can happen in this DNA. While many mutations are harmless, others can cause problems, like allowing cells to grow uncontrollably, which is how cancer begins. Some people inherit certain genetic mutations from their parents that make them more vulnerable to developing lung cancer. These mutations can affect how our cells repair damage, how they grow, and how they respond to harmful factors like cigarette smoke or chemicals in the air.

**- \*\*How Genetics Influences Lung Cancer Risk\*\***

Our genes can influence lung cancer risk in a few different ways:

1**. \*\*DNA Repair Mechanisms\*\*:** Some people have genes that help their cells repair DNA damage. If these repair systems aren’t working as well as they should, it can lead to more mutations that cause cancer. People with certain genetic variations may have less efficient DNA repair, which could make them more susceptible to cancer, especially after exposure to environmental toxins like tobacco smoke.

**2. \*\*Cell Growth and Division\*\*:** Some genetic mutations can affect how our cells grow and divide. Normally, our cells grow, divide, and die in an organized way. But when specific genes are mutated, this process can go awry, and cells can start growing uncontrollably, forming a tumor. Mutations in genes that control cell growth, like TP53 (a tumor suppressor gene), are linked to lung cancer in some families.

**3. \*\*Increased Sensitivity to Carcinogens\*\*:** Some people may have genes that make their bodies more sensitive to carcinogens, substances that can cause cancer. If someone has a genetic predisposition that makes them more vulnerable to the harmful effects of cigarette smoke or pollution, their risk of lung cancer is higher. This is why even non-smokers with certain genetic traits can develop lung cancer.

**- \*\*Gender and Genetic Predisposition\*\***

Interestingly, genetic predisposition to lung cancer can also interact with gender. Women who don’t smoke, for example, may have a higher risk of developing lung cancer than men who don’t smoke. Some studies suggest that women’s bodies may be more sensitive to the effects of smoking and certain genetic mutations. The exact reasons for this are still being studied, but it highlights how genetics and gender can combine to affect cancer risk.

- **\*\*How Genetics Helps in Understanding Lung Cancer\*\***

Research into the genetics of lung cancer is growing, and understanding genetic predisposition is helping scientists find new ways to treat the disease. For instance, people with certain genetic mutations may respond better to targeted therapies, treatments that focus on specific weaknesses in cancer cells. One of the most exciting developments in lung cancer treatment involves drugs that target mutations in the EGFR gene, which have been shown to shrink tumors in people with that specific mutation. Knowing your genetic predisposition can also help doctors make better decisions about screening and prevention. If you have a family history of lung cancer or certain genetic markers, doctors may recommend more frequent screenings, even if you’re a non-smoker. This can help catch the disease earlier when it’s more treatable.

**7. \*\*Age and Gender\*\***

Lung cancer is more common in older adults, typically those over the age of 60. The risk of developing lung cancer increases as you age, likely because the damage to your lungs accumulates over time. Interestingly, lung cancer rates are rising in women, partly due to changes in smoking patterns over the years. Women who smoke may also be more sensitive to the harmful effects of tobacco compared to men, but researchers are still studying this.

**8. \*\*Previous Lung Diseases\*\***

People who have a history of chronic lung diseases, such as chronic obstructive pulmonary disease (COPD) or pulmonary fibrosis, may have a higher risk of developing lung cancer. These diseases can cause long-term damage to the lungs, making them more vulnerable to cancer. Additionally, a history of other cancers can increase your risk of lung cancer, especially if you’ve had radiation therapy in the chest area.

**9. \*\*Diet and Lifestyle Factors\*\***

While smoking and pollution are the primary causes of lung cancer, other factors like diet and overall lifestyle can also play a role. A poor diet lacking in fruits and vegetables may lower the body’s ability to repair damaged cells, which can increase the risk of cancer. Staying active and maintaining a healthy weight can improve lung function and may reduce the likelihood of developing lung cancer.

**\*\*Chapter 4: Types of Lung Cancer\*\***

Lung cancer mainly comes in two types: non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC). Both types affect the lungs but behave differently, and understanding these differences helps doctors figure out the best way to treat them.

**4.1\*\*Non-Small Cell Lung Cancer (NSCLC)\*\***

Non-small cell lung cancer is the more common of the two types, making up about 80-85% of all lung cancer cases. It grows more slowly than small cell lung cancer, and there are three main types within NSCLC. Non-small cell lung cancer (NSCLC) is the most common type of lung cancer, making up about 80-85% of all lung cancer cases. It’s a broad group of cancers that starts in the cells of the lungs and can develop in different parts of the lung. Even though it’s the most common, NSCLC is a bit more treatable than small cell lung cancer because it tends to grow more slowly and doesn’t spread as quickly. Let’s take a deeper look at what NSCLC is, how it develops, and how it can be treated.

**-4.2 \*\*What is NSCLC?\*\***

NSCLC is not just one disease but a collection of several different cancers that start in the lungs. These cancers form in the cells of the lungs, which are responsible for exchanging oxygen and carbon dioxide in our bodies. The three main types of NSCLC are:

**4.21. \*\*Adenocarcinoma\*\*:** This type of cancer starts in the outer parts of the lungs and is the most common form of NSCLC. It's often found in people who don't smoke, though smokers can get it too. Adenocarcinoma tends to grow more slowly than other types, and it often develops in people who are older.

**4.22. \*\*Squamous Cell Carcinoma**\*\*: This type of cancer forms in the airways (bronchi) of the lungs. It is strongly linked to smoking. Squamous cell carcinoma tends to develop in the central parts of the lungs, closer to the trachea, and can cause coughing, shortness of breath, and chest pain.

**4.33. \*\*Large Cell Carcinoma\*\*:** This type of NSCLC can grow anywhere in the lung and tends to grow more quickly than adenocarcinoma or squamous cell carcinoma. It’s a less common form of NSCLC, but it can be more aggressive, spreading to other parts of the body more rapidly.

**-4.3 \*\*How Does NSCLC Develop?\*\***

NSCLC starts when normal cells in the lungs begin to grow uncontrollably. Our lungs are made up of millions of tiny cells, and these cells divide regularly to replace old cells. But sometimes, something goes wrong in this process, and a cell starts to divide and grow out of control, forming a tumor. The tumor may stay in one part of the lung at first, but over time, it can grow larger and spread to other parts of the lung or to other areas of the body, like the lymph nodes, bones, liver, or brain. This is called metastasis, and it’s what makes cancer more dangerous and harder to treat.

**- 4.4\*\*What Causes NSCLC?\*\***

The main risk factor for developing NSCLC is smoking. About 80% of people who get lung cancer are smokers or former smokers. Smoking introduces harmful chemicals into the lungs that can damage the cells and cause cancer over time. However, it’s important to note that non-smokers can also develop NSCLC, especially people exposed to secondhand smoke, air pollution, or chemicals at work. Additionally, people with a family history of lung cancer may have a higher risk, even if they’ve never smoked.

**-4.5 \*\*Symptoms of NSCLC\*\***

At first, NSCLC might not cause any obvious symptoms, or it might cause symptoms that are easy to ignore, like a cough or feeling tired. As the cancer grows, though, it can cause more serious symptoms. Common symptoms include:

- Persistent coughing that doesn’t go away

- Shortness of breath or wheezing

- Chest pain or discomfort

- Unexplained weight loss

- Coughing up blood or rust-colored sputum

- Fatigue or feeling unusually tired

- Hoarseness or a change in voice

Because these symptoms can be caused by other conditions, people often ignore them until they get worse. This is why lung cancer is often diagnosed at later stages, when it’s harder to treat.

**- 4.6\*\*How is NSCLC Treated?\*\***

Treatment for NSCLC depends on several factors, including the stage of the cancer (how far it has spread), the type of NSCLC, and the person’s overall health. Common treatments include:

**4.61. \*\*Surgery\*\*:** If the cancer is found early and hasn’t spread, surgery may be an option. The goal of surgery is to remove the tumor or the part of the lung affected by cancer. In some cases, the entire lung may need to be removed (a procedure called a lobectomy or pneumonectomy).

**4.62. \*\*Chemotherapy\*\*:** Chemotherapy uses drugs to kill cancer cells or stop them from growing. It’s often used when the cancer has spread or can’t be removed by surgery.

**4.63. \*\*Radiation Therapy\*\*:** Radiation uses high-energy rays to kill cancer cells. It can be used on its own or along with surgery or chemotherapy, especially if the cancer has spread to nearby areas.

**4.64. \*\*Targeted Therapy\*\*:** Some types of NSCLC have specific genetic changes that make them more vulnerable to targeted treatments. These drugs focus on these genetic changes and can block the cancer cells from growing.

**4.65. \*\*Immunotherapy**\*\*: This is a newer type of treatment that helps the body’s immune system recognize and fight cancer cells. It can be used for advanced-stage NSCLC or in cases where other treatments haven’t worked.

**4.7\*\*Small Cell Lung Cancer (SCLC)\*\***

Small cell lung cancer is less common, making up about 10-15% of all lung cancers, but it’s more aggressive and spreads faster than NSCLC. It often begins in the larger airways of the lungs and is strongly linked to smoking. Because SCLC grows and spreads quickly, it’s usually diagnosed in its later stages, making it harder to treat. The treatment for small cell lung cancer often includes chemotherapy and radiation, as surgery is less effective due to how quickly it spreads. Small cell lung cancer (SCLC) is a type of lung cancer that is much less common than non-small cell lung cancer (NSCLC), but it’s more aggressive and harder to treat. While NSCLC accounts for about 80-85% of all lung cancers, small cell lung cancer makes up only around 10-15% of cases. SCLC tends to grow and spread very quickly, making it a more challenging disease to manage. Let’s dive into what small cell lung cancer is, how it develops, and how it can be treated in a way that’s easy to understand.

**4.8- \*\*What is Small Cell Lung Cancer (SCLC)?\*\***

Small cell lung cancer is a type of cancer that begins in the lungs, specifically in the cells that line the airways. It’s called “small cell” because the cancer cells are much smaller compared to other types of lung cancer cells. Despite their size, these cells can grow rapidly and form large tumors that spread quickly throughout the body. SCLC is most commonly found in the central part of the lungs, near the bronchi (the large airways that lead into the lungs), and it often involves both lungs by the time it's diagnosed. This is one reason why small cell lung cancer is so dangerous – it doesn’t just stay in one place; it spreads fast.

**Evaluation metrics VGG19 ResNet50 Inception-**

**ResNetv2 DenseNet121**

**Accuracy 92.1% 99 99.7 99.4**

**Specificity 92.5% 99 99.7 99.4**

**Recall 92.1% 99 99.7 99.4**

**F1 score 92.4% 99 99.7 99.4**

**Model Adam-Learning rate used**

**VGG19 0.00001**

**ResNet50 0.0001**

**Inception-ResNetv1 0.00001**

**DenseNet121 0.0001**

Figure 1. Process of carcinogenesis (Chegg.com, 2021).

Figure 2. Three phases of carcinogenesis (Chegg.com, 2021)

Figure 3. Types of Non-Small Cell Lung Cancer (NSCLC) (Lynne Eldridge, 2021)

**-4.9 \*\*Causes of Small Cell Lung Cancer\*\***

The main cause of small cell lung cancer is smoking. About 90% of people diagnosed with SCLC are either current or former smokers. The harmful chemicals in tobacco smoke damage the lungs over time, leading to mutations in the lung cells that can eventually cause cancer. The more a person smokes and the longer they smoke, the higher their risk of developing small cell lung cancer. However, non-smokers can also get SCLC, though it's much rarer. Exposure to secondhand smoke, certain chemicals at work, or environmental toxins may increase the risk for non-smokers, but smoking is still the leading cause.

**- \*\*How Does Small Cell Lung Cancer Develop?\*\***

Small cell lung cancer starts when healthy cells in the lungs begin to grow uncontrollably. Normally, our body’s cells divide and grow in an organized way to replace old or damaged cells. But with cancer, this process goes wrong. The cells keep growing and dividing, forming a tumor. As the tumor gets bigger, cancer cells can spread to other parts of the body through the blood or lymphatic system. This spreading is called metastasis. In SCLC, the cancer cells grow very quickly, and they often spread beyond the lungs to other areas like the liver, brain, or bones. Because of this rapid spread, SCLC is often diagnosed at an advanced stage, which makes it harder to treat.

**- \*\*Symptoms of Small Cell Lung Cancer\*\***

Small cell lung cancer can cause a variety of symptoms, but because the cancer grows quickly, these symptoms often appear suddenly and can worsen fast. Common symptoms include:

- Coughing: This could be a persistent cough that doesn’t go away or worsens over time.

- Chest pain: People with SCLC may feel pain or discomfort in the chest, especially when coughing or breathing deeply.

- Shortness of breath: SCLC can block the airways or cause fluid buildup in the lungs, making it hard to breathe.

- Wheezing: A whistling sound when breathing, which happens if the airways are narrowed or blocked.

- Coughing up blood: This could be a sign that the tumor is bleeding or irritating the airways.

- Unexplained weight loss: Rapid, unexplained weight loss can be a sign of cancer.

- Fatigue: Feeling very tired, weak, or low on energy, even after rest.

- Hoarseness: A change in the voice can happen if the tumor presses on the nerves that control the vocal cords.

Because these symptoms can also be caused by other conditions, like a cold or pneumonia, people might not immediately think they are related to cancer. This is one reason why SCLC is often diagnosed in later stages.

(a)

(b)

**- \*\*Treatment for Small Cell Lung Cancer\*\***

Small cell lung cancer grows quickly, so doctors often treat it aggressively. However, because it spreads so fast, SCLC is rarely found in its early stages, which can make treatment more difficult. The main treatments for SCLC include:

1. \*\*Chemotherapy\*\*: Chemotherapy uses drugs to kill or stop cancer cells from growing. It’s the most common treatment for small cell lung cancer because it can target cancer cells throughout the body, including those that have spread outside the lungs. Since SCLC spreads quickly, chemotherapy is often used as the first line of treatment.

2. \*\*Radiation Therapy\*\*: Radiation uses high-energy rays to kill cancer cells. It’s often used in combination with chemotherapy, especially if the cancer is limited to one part of the lung. It can also help shrink tumors and relieve symptoms, like pain or difficulty breathing.

3. \*\*Surgery\*\*: Surgery is less common for SCLC because the cancer usually spreads too quickly to be treated with surgery alone. However, if the cancer is found early and hasn’t spread much, surgery may be an option to remove the tumor.

4. \*\*Immunotherapy\*\*: Immunotherapy is a newer treatment that helps the immune system recognize and fight cancer cells. It’s sometimes used for advanced SCLC, especially if chemotherapy alone isn’t effective.

5. \*\*Targeted Therapy\*\*: This treatment uses drugs that target specific changes in the cancer cells. It’s still being studied for small cell lung cancer, but it’s an option in some cases where the cancer has certain genetic mutations.

- \*\*Final Thoughts\*\*

Small cell lung cancer is a serious and fast-growing type of lung cancer, mostly caused by smoking. It’s more aggressive than other types of lung cancer, spreading quickly to other parts of the body. While it’s harder to treat, there are several treatment options available, including chemotherapy, radiation, and newer therapies like immunotherapy. The key to managing small cell lung cancer is catching it as early as possible and starting treatment right away. If you or someone you know has symptoms of lung cancer, it’s important to see a doctor for proper testing and diagnosis.

**\*\*Chapter 5: Symptoms and Early Diagnosis\*\***

Lung cancer can be tricky because its symptoms often don’t show up until it’s already advanced. However, in some cases, there are signs that can show up earlier. It's important to pay attention to your body and speak with a doctor if you notice any of these changes. Catching it early can make a big difference in treatment options and outcomes.

5.1\*\*Common Symptoms\*\*

Here are some common symptoms and early signs of lung cancer that people might experience:

1. \*\*Persistent Cough\*\*

A cough that doesn’t go away or a cough that gets worse over time is one of the most common early signs of lung cancer. If you’ve had a cough for a while, and it’s not improving, it could be a sign that something is wrong. This cough might sound different than usual, and you might also feel like you can’t shake it, no matter how much you rest or drink fluids.

2. \*\*Coughing Up Blood\*\*

If you start coughing up blood or rust-colored sputum (mucus), it's important to see a doctor right away. It could be a sign of lung cancer or another serious condition. Even small amounts of blood should not be ignored, as it can indicate something going wrong in the lungs.

3. \*\*Shortness of Breath\*\*

Lung cancer can make it harder to breathe, especially if the tumor is blocking one of the airways or causing fluid to build up in the lungs. If you start feeling unusually short of breath, even when doing things you could normally do without any trouble, like climbing stairs or walking a short distance, this could be a warning sign.

4. \*\*Chest Pain or Discomfort\*\*

If you experience unexplained chest pain or discomfort, it’s important to take it seriously. The pain could be constant, or it could get worse when you cough, laugh, or take a deep breath. Lung cancer can cause pain if a tumor presses on the chest wall or the nerves around the lungs.

5. \*\*Wheezing\*\*

Wheezing is a high-pitched whistling sound that can happen when you breathe. It might occur because the cancer is blocking your airways or causing swelling in the lungs. If you’re wheezing and it doesn’t go away or seems to worsen, it might be worth having it checked out by a doctor.

6. \*\*Unexplained Weight Loss\*\*

Unexplained weight loss, meaning you’re losing weight without trying to, can be an early sign of many cancers, including lung cancer. If you’re eating well but noticing your clothes are getting looser, or if you’re dropping pounds without any other explanation, it’s a good idea to speak with your doctor.

7. \*\*Fatigue or Feeling Tired All the Time\*\*

Lung cancer can cause fatigue or tiredness, even if you’re getting enough rest. If you’re suddenly feeling exhausted all the time, even after a good night’s sleep or not doing much, it could be a symptom. This kind of fatigue is different from just feeling a bit tired; it’s a deep tiredness that doesn’t go away easily.

8. \*\*Hoarseness or a Change in Voice\*\*

If your voice suddenly becomes hoarse or changes and it doesn’t go away, it might be a sign that something is affecting your vocal cords. Tumors in the lung can sometimes press on the nerves that control the voice box, leading to hoarseness or a raspy voice.

9. \*\*Loss of Appetite\*\*

Lung cancer, like many other cancers, can cause a loss of appetite. If you notice that food just doesn’t sound as appealing as it used to, or if you feel full even after eating only a small amount, it could be a warning sign. This can also be linked to feeling nauseous or having an upset stomach.

10. \*\*Swelling in the Face or Neck\*\*

Sometimes, a tumor in the lung can block the veins in the chest area, leading to swelling in the face, neck, or upper chest. If you notice that your face or neck is puffing up, or if your shirt collar feels tighter, it’s something worth discussing with a doctor.

11. \*\*Frequent Respiratory Infections\*\*

If you find yourself getting a lot of respiratory infections like pneumonia or bronchitis, it could be a sign that something is going on with your lungs. Lung cancer can make it easier for infections to take hold because it can affect how your lungs work and the way your immune system fights off illness. If you’re frequently sick with respiratory issues, it’s worth having a conversation with your doctor.

12. \*\*Pain in the Shoulder or Back\*\*

Lung cancer can sometimes cause pain that radiates to other parts of the body, like the shoulders or back. This happens because the tumors in the lungs can put pressure on nerves or other organs, which can lead to discomfort or pain in places far away from the lungs themselves. If you’re experiencing unexplained pain in your shoulder or back that doesn’t go away, it’s something to get checked out.

13. \*\*Trouble Swallowing\*\*

If lung cancer spreads or grows large enough, it can press on the esophagus (the tube that carries food from your mouth to your stomach). This can make swallowing difficult or painful, or you may feel like food is getting stuck. If you have a sudden or persistent problem swallowing, this could be another sign that something’s wrong with your lungs or chest area.

14. \*\*Swollen Lymph Nodes\*\*

Your lymph nodes are small, bean-shaped structures that are part of your immune system. They can swell when there’s an infection in your body, but they can also swell when cancer is present. If you notice swelling in your neck, under your arms, or in your groin area, it could be because the cancer has spread to your lymph nodes. In lung cancer, the lymph nodes near the lungs or chest may become enlarged.

15. \*\*Changes in Appetite or Digestion\*\*

Along with losing interest in food, lung cancer can also mess with your digestive system. Some people experience nausea, vomiting, or stomach discomfort, even if they haven’t eaten anything unusual. In rare cases, lung cancer can release chemicals that affect your digestion or make you feel queasy.

5.2\*\*Why Should You Pay Attention to These Symptoms?\*\*

It’s important to remember that these symptoms can be caused by conditions other than lung cancer, like a cold, a respiratory infection, or allergies. But if any of these signs stick around for a long time or get worse over time, it’s essential to see a doctor. The earlier lung cancer is caught, the more options there are for treatment. Even if it turns out to be something else, getting it checked can give you peace of mind. If you’re at higher risk—say, if you’ve been a smoker or have a family history of lung cancer—it's especially important to stay alert to these symptoms and talk to your doctor about screening options. Your health is your priority, so don’t hesitate to ask questions and get checked out if anything feels off.

**5.3\*\*Difference Between Early Stage and Late Stage Symptoms\*\***

1.\*\*Early Stage Lung Cancer Symptoms\*\*

In the early stages of lung cancer, the symptoms are often subtle or might not be noticeable at all. If symptoms do appear, they tend to be mild and can easily be mistaken for other common issues like a cold, flu, or even allergies. This is one reason why early-stage lung cancer is often harder to catch. People with early-stage lung cancer may experience:

1. \*\*A Mild, Persistent Cough\*\*: You might have a cough that doesn’t go away after a few weeks, but it might not be too bad. It’s easy to brush off a cough as just a lingering cold, especially if it’s not causing much discomfort.

2. \*\*Mild Shortness of Breath\*\*: You might feel a little winded after doing something physical, like climbing stairs or walking up a hill, but it’s not necessarily severe. You could just think it's because you're out of shape, or maybe a sign of aging.

3. \*\*Slight Chest Pain or Discomfort\*\*: There could be some discomfort in the chest area, but it’s usually mild and not constant. It might feel like a tightness or a dull ache, which can often be mistaken for muscle soreness or heartburn.

4. \*\*Feeling Tired or Fatigued\*\*: Early on, some people feel a little more tired than usual. It’s not necessarily extreme fatigue, but you might notice you need to take naps more often or feel a bit low on energy.

5. \*\*Occasional Wheezing\*\*: If your airways are a little irritated by a tumor, you might notice a slight wheezing sound when breathing, but it usually isn’t noticeable all the time. You might think it’s just a mild asthma flare-up or seasonal allergies.

**- 5.4\*\*Late Stage Lung Cancer Symptoms\*\***

As lung cancer progresses to later stages, the symptoms become more obvious and more severe. This happens because the tumor grows bigger and can start affecting more parts of the lungs and other organs. In late-stage lung cancer, people might experience:

1. \*\*A Persistent, Severe Cough\*\*: The cough becomes much more noticeable and doesn’t go away. It can be deep, painful, and may even worsen over time. You might also start coughing up blood or blood-streaked mucus, which is a more concerning sign.

2. \*\*Severe Shortness of Breath\*\*: Breathing becomes noticeably harder, even during simple activities like walking across the room or getting out of bed. The lungs may be filling with fluid, or the tumor could be blocking the airways, making it difficult to breathe.

3. \*\*Intense Chest Pain\*\*: As the cancer grows, it might start pressing against the chest wall, causing pain that’s sharper and more consistent. The pain could get worse when you cough or take a deep breath.

4. \*\*Weight Loss and Loss of Appetite\*\*: Unexplained weight loss becomes more noticeable in later stages. You might find you don’t feel hungry, or you might feel full after eating just a little. This can be due to the cancer affecting your metabolism or digestive system.

5. \*\*Extreme Fatigue\*\*: The fatigue becomes much worse, and no matter how much you rest, you might feel drained all the time. This kind of fatigue is different from just being tired – it’s an overwhelming, persistent tiredness that doesn’t go away.

6. \*\*Wheezing and Hoarseness\*\*: Wheezing becomes more pronounced as the tumor grows, and it might be harder to get air through the narrowed airways. Additionally, you may notice your voice sounding hoarse or raspy, which could be a sign that the cancer is affecting the nerves around the vocal cords.

7. \*\*Swelling in the Face, Neck, or Chest\*\*: As the tumor spreads or grows larger, it can block blood flow from the upper part of your body, leading to swelling in your face, neck, or chest. This can also make your collar or shirt feel tighter than usual.

8. \*\*Bone Pain or Pain in Other Areas\*\*: If the cancer has spread to other parts of the body (like the bones), you might start feeling pain in places like your back, shoulders, or hips. This pain can be persistent and might not go away with regular pain relievers.

**-5.5 \*\*Key Differences Between Early and Late Stage Symptoms**\*\*

- \*\*Severity\*\*: In the early stages, symptoms are usually mild and easy to ignore, while in the later stages, the symptoms become stronger and more disruptive to daily life.

- \*\*Frequency\*\*: Early-stage symptoms might come and go, while in the later stages, they are more constant and often worsen over time.

- \*\*Type of Symptoms\*\*: In the early stages, a mild cough, slight shortness of breath, or feeling a little more tired than usual might be the only signs. By the time the cancer reaches the later stages, more severe symptoms like pain, weight loss, and swelling appear.

- \*\*Spread of Cancer\*\*: In early-stage cancer, the tumor is usually confined to one area in the lungs, but by late stage, the cancer may have spread to other organs or parts of the body.

- 5.6\*\*Why It’s Important to Be Aware of Both Early and Late Symptoms\*\*

Lung cancer can often be mistaken for other less serious conditions in the early stages, which is why many people don’t get checked until it’s more advanced. Unfortunately, by the time the cancer reaches its later stages, it’s harder to treat effectively. This is why it's crucial to listen to your body and pay attention to any changes, even if they seem small at first. If you notice symptoms, especially if they’re persistent or getting worse over time, it’s important to talk to a doctor as soon as possible. The key takeaway is: the sooner lung cancer is detected, the better the chances for successful treatment. So, don’t ignore those small early symptoms – they could make a big difference in your health down the line.

**5.7\*\*Importance of Early Diagnosis\*\***

Early diagnosis of lung cancer is really important because it can make a big difference in how well the treatment works and how much time someone has to fight the disease. Let's break it down in simple terms:

1. \*\*Better Treatment Options\*\*

When lung cancer is caught early, the tumor is usually smaller and hasn’t spread as much. This means there are more treatment options available, and doctors can target the cancer more effectively. For example, surgery might still be an option in the early stages to remove the tumor. In later stages, the cancer may have spread too much, making surgery more difficult or impossible.

2. \*\*Higher Chance of Survival\*\*

The earlier lung cancer is found, the better the chances of treating it successfully. In the early stages, the cancer is more likely to respond to treatments like surgery, chemotherapy, or radiation. In fact, early detection significantly increases the survival rates compared to when the cancer is diagnosed later, when it’s harder to treat.

3. \*\*Less Aggressive Treatment Needed\*\*

If lung cancer is found early, the treatment might be less aggressive or intense. For example, if the cancer is still small and localized, it could be removed with surgery or treated with targeted therapy, which can be more focused. In advanced stages, the treatments can be much harsher, involving chemotherapy, radiation, or immunotherapy, which can cause more side effects and take a bigger toll on the body.

4. \*\*Better Quality of Life\*\*

When lung cancer is diagnosed early, there’s a better chance of keeping the cancer under control without it interfering too much with your daily life. Treatment might be less disruptive, and people may be able to continue with more of their regular activities. In later stages, cancer treatments might cause more side effects, and it can be harder to maintain a good quality of life.

5. \*\*Less Spread to Other Parts of the Body\*\*

Lung cancer tends to spread quickly. If it’s caught early, it’s less likely to have spread to other organs like the liver, brain, or bones. The more the cancer spreads, the harder it becomes to treat effectively. Early diagnosis means the cancer is more likely to be confined to one area, making it easier for doctors to manage and remove.

6. \*\*Peace of Mind\*\*

Finding out early that you have lung cancer means you can start treatment sooner, which can help reduce anxiety and give you more control over your health. Early diagnosis can also help people feel more hopeful, knowing they have more treatment options and a better chance of recovery.

7. \*\*Lower Treatment Costs\*\*

Early diagnosis can sometimes mean fewer or less expensive treatments. When lung cancer is found early, doctors can focus on less invasive and less costly treatments, which can make the overall treatment process less expensive. In later stages, treatments might need to be more intensive, which can quickly add up.

5.8\*\*Why is Early Diagnosis Hard?\*\*

Unfortunately, lung cancer is often not detected early because it doesn't usually cause symptoms until it's more advanced. And when symptoms do appear, they can often look like other, less serious health problems (like a cough or a cold). This is why it’s important to pay attention to your health and talk to a doctor if something feels off, especially if you’re at higher risk for lung cancer (like if you smoke or have a family history of cancer). Regular screenings for people at high risk (such as long-time smokers) can help detect lung cancer early, even before symptoms show up. These screenings are a great tool to catch cancer early and give people the best possible chance for a successful treatment outcome.

5.9\*\*Survival Rate with Early Detection\*\*

Early detection of lung cancer significantly improves survival rates. When lung cancer is identified at an early stage, before it has spread, treatment options are more effective, leading to better outcomes. For instance, research indicates that patients diagnosed through regular screenings had an 81% lung cancer-specific survival rate at 20 years. In India, where lung cancer is often diagnosed at advanced stages, early diagnosis can be particularly beneficial. Recognizing symptoms like persistent chest pain and coughing, and seeking timely medical advice, can lead to earlier detection and improved survival rates.

**\*\*Challenges in Early Diagnosis\*\***

Detecting lung cancer early is tricky because of a few challenges:

1. \*\*No Clear Symptoms Early On\*\*: In the beginning, lung cancer often doesn’t cause any noticeable symptoms. People might just have a mild cough or feel a bit short of breath, which can easily be confused with something less serious, like a cold.

2. \*\*Screening Isn’t Perfect\*\*: While scans can help catch lung cancer early, they aren’t foolproof. They’re mainly recommended for high-risk people, like heavy smokers, but not everyone who could be at risk gets checked. Sometimes these scans can also give false alarms, leading to extra tests, or miss cancer that’s actually there.

3. \*\*Cost and Access\*\*: Not everyone can afford or easily access the screenings that could catch lung cancer early. Even for those at high risk, getting regular checks isn’t always possible depending on where you live or your financial situation.

4. \*\*Stigma Around Smoking\*\*: Since smoking is a big risk factor for lung cancer, some people feel ashamed or hesitant to get checked because they worry about being judged. This can stop people from seeking help when they need it.

5. \*\*Cancer Grows Differently for Everyone\*\*: Lung cancer doesn’t always act the same way. Some cancers grow slowly, while others spread fast. This makes it hard to know when or how the disease will show up.

6. \*\*Lack of Awareness\*\*: Many people don’t fully understand the risks of lung cancer or how important it is to catch it early. Getting the word out and making people aware of the signs and the need for screenings is still a big challenge.

**\*\*Role of Screening Programs\*\***

Screening programs play a big role in catching lung cancer early, when it's easier to treat and has a better chance of being cured. These programs involve regular tests, like low-dose CT scans, that can find lung cancer before symptoms show up. Here’s how they help:

1. \*\*Catching Cancer Early\*\*: If lung cancer is detected early, it’s much more likely to be treated successfully. Screening helps find cancer in its early stages, when it’s still small and hasn’t spread to other parts of the body.

2. \*\*For High-Risk People\*\*: Screening programs are mainly aimed at people who are at higher risk of lung cancer, like long-term smokers. If you’re at risk, regular screening can help spot any problems before you even notice symptoms.

3. \*\*Saving Lives\*\*: Studies show that screening can reduce the risk of dying from lung cancer by finding tumors early and giving doctors a better chance to treat them effectively. Early treatment can make a huge difference in survival rates.

4. \*\*Peace of Mind\*\*: For people at high risk, knowing that they’re getting checked regularly can provide some peace of mind. It can help reduce anxiety about the unknown and make them feel more in control of their health.

5. \*\*Encouraging Healthy Habits\*\*: Screening programs can also be a way to encourage people to take care of their lungs by quitting smoking or avoiding exposure to harmful substances. Knowing they’re at higher risk can motivate people to make healthier choices.

**\*\*Chapter 6: Summary and Conclusions\*\***

Lung cancer remains a global health crisis due to its high mortality, late-stage diagnosis, and significant risk factors like smoking, pollution, and occupational exposures. NSCLC and SCLC differ in prevalence and aggressiveness, with NSCLC being more common and treatable if caught early, while SCLC is aggressive and often diagnosed late. Smoking is the leading cause, responsible for 85% of cases, but secondhand smoke, air pollution, radon, and workplace carcinogens like asbestos, diesel exhaust, and silica dust also contribute significantly. Genetic predisposition, particularly mutations in genes like TP53 and EGFR, increases susceptibility, with women showing higher risks among non-smokers. Occupational exposures in industries like construction and mining elevate risk, though protective measures can mitigate this. Symptoms range from mild early signs like a persistent cough to severe late-stage manifestations such as weight loss, bone pain, and swelling, emphasizing the need for early diagnosis. Early detection through screening, especially for high-risk groups like long-term smokers, significantly improves survival rates (up to 81% at 20 years) and treatment outcomes. Challenges in early diagnosis include subtle symptoms, limited screening access, and stigma, underscoring the need for better awareness and screening programs. Addressing lung cancer requires global efforts to reduce risk factors, improve early detection, and enhance treatment accessibility to improve survival rates and quality of life.

**\*\*Chapter 7: Scope for Future Work\*\***

Future research should focus on improving early detection methods, such as developing more accessible, accurate, and affordable screening tools for diverse populations, particularly in low- and middle-income countries. Advancements in targeted therapies for genetic mutations (e.g., EGFR) and immunotherapy for SCLC could enhance treatment outcomes. Public health initiatives should prioritize reducing smoking rates, improving air quality, and enforcing stricter workplace safety regulations to minimize exposure to carcinogens like asbestos and diesel exhaust. Additionally, exploring the genetic predisposition in non-smokers and the gender-specific risks in women can lead to more personalized prevention and treatment strategies. Increasing public awareness about early symptoms, reducing stigma around screening, and expanding access to screening programs for high-risk groups are critical steps to improve early diagnosis rates. Finally, research into the role of diet, lifestyle, and environmental factors in lung cancer prevention can provide new avenues for reducing incidence rates globally.

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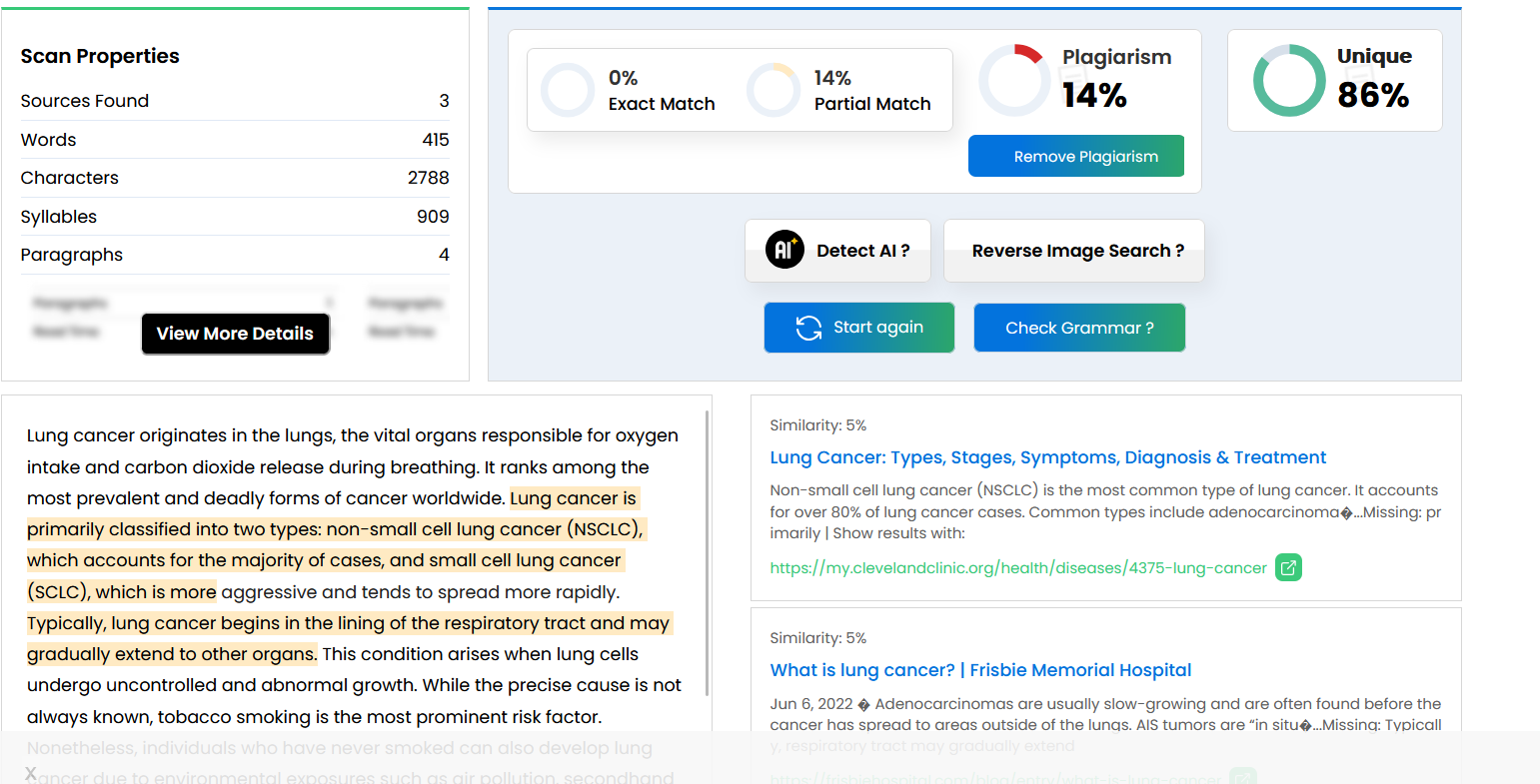
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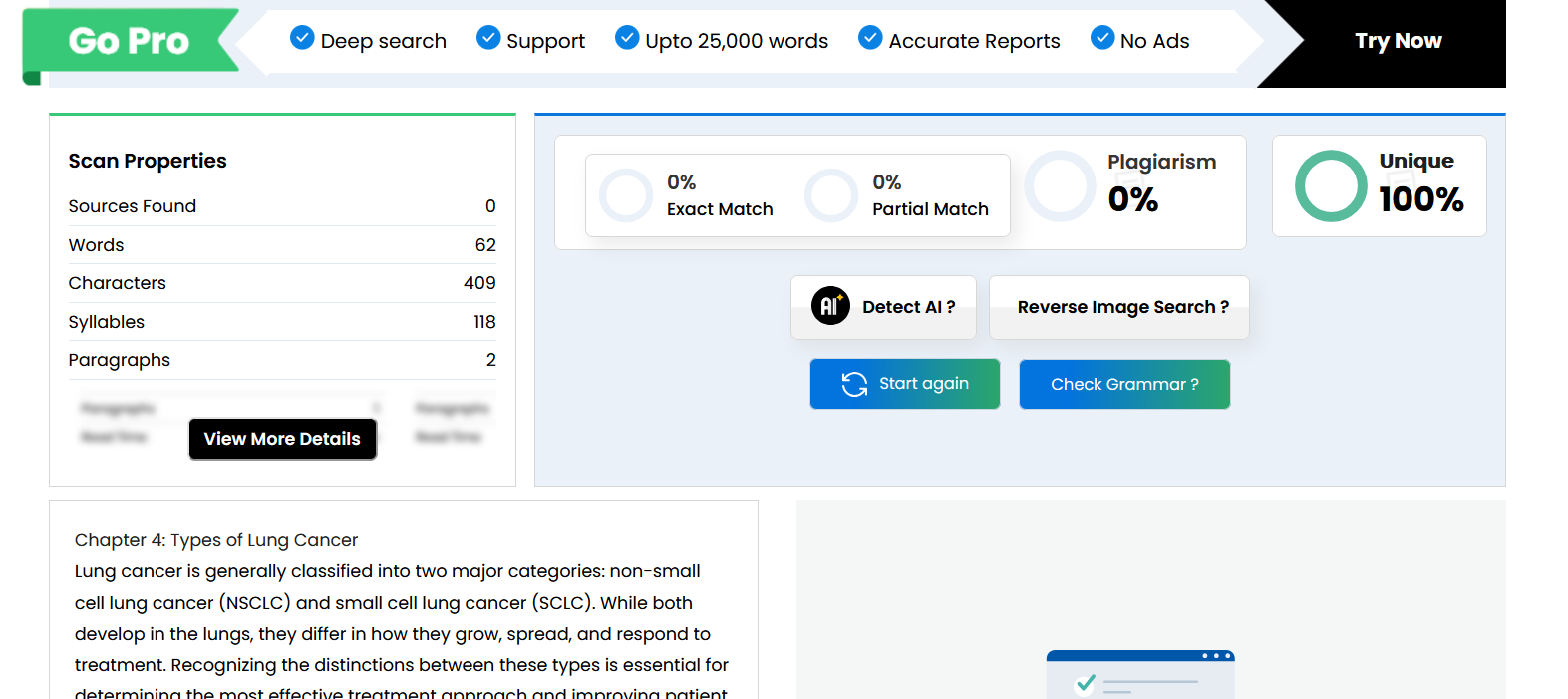
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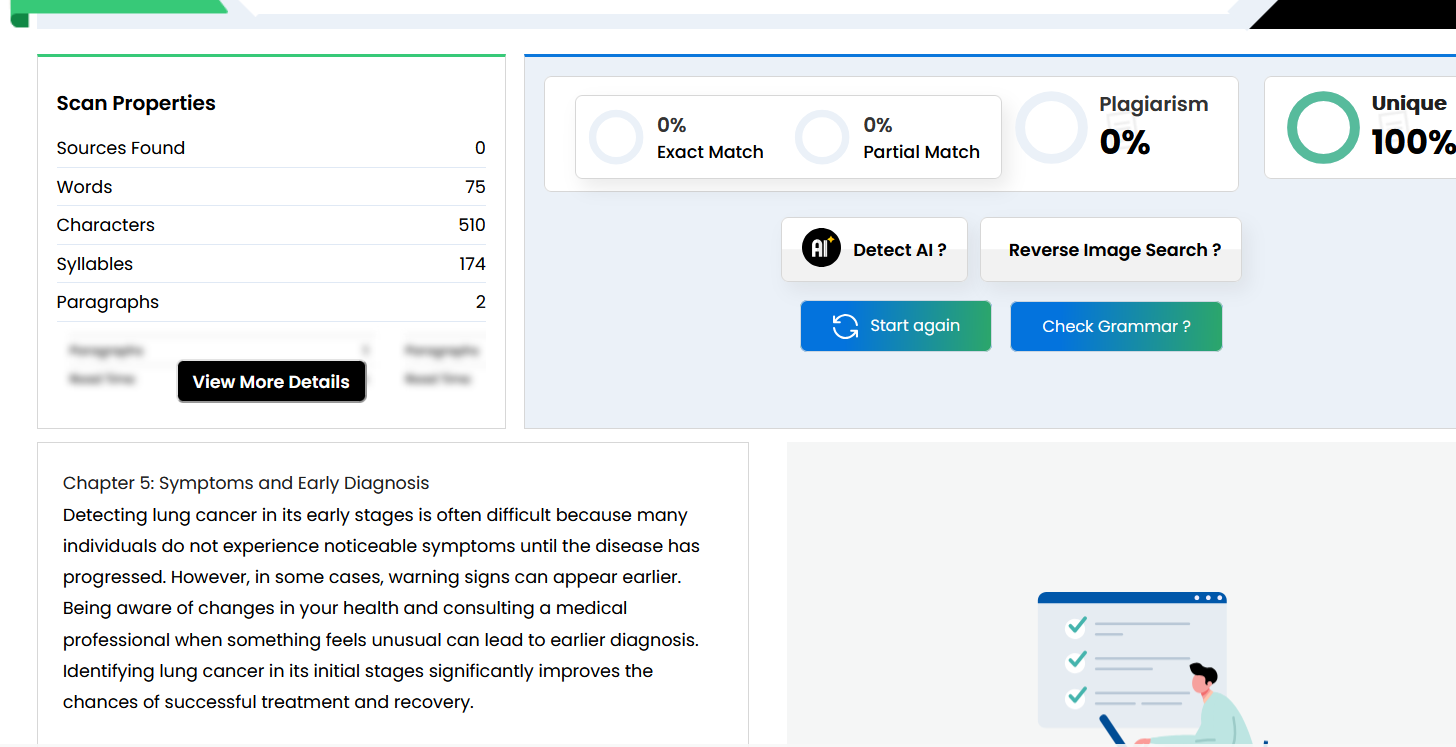
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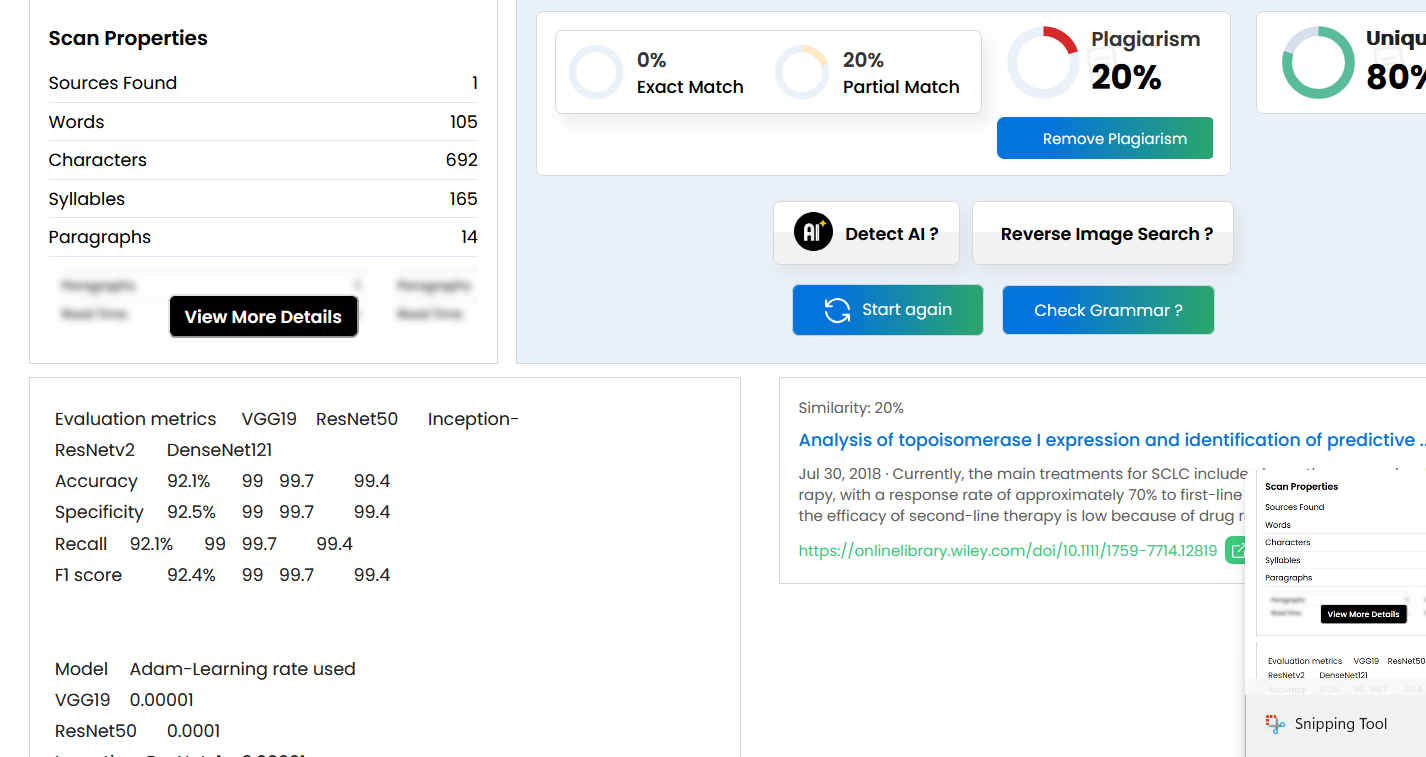
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AI-generated content may be incorrect.**

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