Expert System For COVID-19 And Other Respiratory Diseases

Project Report

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Abstract: The rising number of COVID symptomes has increased healthcare practitioners' workloads, rendering precise and efficient management of dynamic patient information complicated, if not impossible. A shortage of healthcare providers and qualified medical personnel to accommodate the increased number of patients exacerbates the problem. In this paper, we have designed an expert system that can take into consideration all the symptoms related to COVID-19 and other respiratory diseases and predict the possible disease. For this, we will find all the symptoms that the patient is having after getting infected. The Expert System will also suggest whether you have to seek immediate medical support or not. The Expert System will help individuals in finding out the chances of getting infected by the COVID-19 Virus and other respiratory diseases. Existing Literature reviews and secondary data have been used for designing the Expert System. In addition to that of COVID-19, it will also tell some of the other respiratory diseases.

Keywords - Covid19, symptoms, Lungs, decision tree, ID3, respiratory diseases

1. Introduction

Covid-19, An infectious disease that has spread havoc in the world right now. COVID stands for coronavirus infectious disease which is novel as no one has seen anything like this before. COVID-19 is a respiratory affliction that affects the respiratory system of the human body like the nose, throat, lungs, windpipe by hindering normal functioning leading to respiratory failure, pneumonia, etc when left untreated causes untimely death.

Coronaviruses are a collection of viruses with nonsegmented, single-stranded, and positive-sense RNA genomes. Apart from infecting a variety of economically important vertebrates (such as pigs and chickens), 6 coronaviruses have been known to infect humans and cause respiratory diseases. Among them, severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV) are zoonotic and highly pathogenic coronaviruses that have resulted in regional and global outbreaks

Coronaviruses possess a distinctive morphology, the name being derived from the outer fringe, or ―corona of the embedded envelope protein.

Coronavirus disease 2019 (COVID-19) has resurfaced as an unforgettable outbreak, and the year 2021 will be recalled for a long time. The novel virus Severe Acute Respiratory Syndrome Coronavirus 2 causes Coronavirus, an infectious disease (SARS-CoV-2) (Home, 2020). This had been recognised in Wuhan, China's Hubei province capital, in December 2019 and has since spread to over 213 countries worldwide (Zhao et al., 2020). The virus has engulfed the whole globe, prompting WHO to declare the Covid flare-up a pandemic (2021). 32.9L people died, and over 15.8Cr people were affected (as of 10th May 2021, WHO).

2. Literature Review

Acute Bronchitis, when the airways of the lungs compress and release mucus, it is called acute bronchitis. This is what causes you to cough. Acute bronchitis, also known as a chest cold, is the most frequent form of bronchitis that lasts less than three weeks. A virus causes acute bronchitis, which generally happens following an upper respiratory infection. Bacteria can cause acute bronchitis, but antibiotics are not prescribed in these circumstances and may not help you recover. Coughing is the most frequent symptom. Coughing up mucus, coughing up blood, wheezing, shortness of breath, rapid heartbeat, fever, and chest pain are some of the other symptoms. (Albert, 2021)

Asthma is a disease that causes the airways to close and swell, as well as release excess mucus. This can make breathing painful, resulting in coughing, whistling (wheezing) on exhalation, and shortness of breath. (Richardson et al., 2006)

Bronchiectasis - Bronchiectasis is a condition where the bronchial tubes of your lungs are permanently damaged, widened, and thickened. These damaged air passages allow bacteria and mucus to build up and pool in your lungs. This results in frequent infections and blockages of the airways. Symptoms of bronchiectasis can take months or even years to develop. Some typical symptoms include:

- chronic daily cough

- coughing up blood
- abnormal sounds or wheezing in the chest with breathing
- shortness of breath
- chest pain
- coughing up large amounts of thick mucus every day
- weight loss
- fatigue
- change in the structure of fingernails and toenails, known as clubbing
- frequent respiratory infections

Bronchiolitis - Bronchiolitis is a common lung infection in young children and infants. It causes inflammation and congestion in the small airways (bronchioles) of the lung. Bronchiolitis is almost always caused by a virus. Typically, the peak time for bronchiolitis is during the winter months. Bronchiolitis starts with symptoms similar to those of a common cold, but then progresses to coughing, wheezing, and sometimes difficulty breathing. Symptoms of bronchiolitis can last for several days to weeks. For the first few days, the signs and symptoms of bronchiolitis are similar to those of a cold:

- Runny nose
- Stuffy nose
- Cough
- A slight fever (not always present)

After this, there may be a week or more of difficulty breathing or a whistling noise when the child breathes out (wheezing). Many infants also have an ear infection

COPD - The study by Agustí, A (2012) reported that Chronic Obstructive pulmonary disease (COPD) is a major respiratory non-communicable disease. It influences around 10% of the adult population and it is predicted that it will be the third reason for death and disability in the world by the year 2020. Persistent, low -level, systemic inflammation is deemed to play a vital pathogenic role in many Non-communicable diseases including COPD. Barnes, P. J. (2000)

pointed out that the inflammatory process in COPD is very distinct from that in asthma, with several inflammatory cells, mediators, inflammatory effects, and response to therapy.

The most common symptoms of COPD are dyspnea, cough, and sputum production and less common but painful symptoms are wheezing, chest tightness, and chest congestion. N. H., & Miravitlles, M. (2013). Other irritants can cause COPD including cigar-smoking, secondhand smoke, pipe smoke. The blend of asthma and smoking raises the risk of COPD even more. The rare genetic disorder alpha-1-antitrypsin deficiency is the cause of some cases of COPD. Other genetic factors likely make certain smokers more sensitive to the disease.

Common cold - The common cold is a viral illness that affects persons of all ages, urging frequent use of over-the-counter and prescription medications and alternative remedies.
A new awareness of the efforts of cytokines in human beings now serves to illustrate some of the symptoms of colds and flu that were first in the realm of myth rather than medicine -eg, fever, anorexia, malaise, chilliness, headache and muscle aches, and pains.
The mechanisms of symptoms of sore throat, rhinorrhoea, sneezing, nasal congestion, cough, watery eyes, and sinus pain are addressed in Eccles, R. (2005)

The common cold is usually caused by one of the various respiratory viruses, most commonly rhinovirus. These viruses, which store in nasal secretions, are easily transmitted through sneezing, coughing, or nose blowing. Signs and symptoms of the common cold involve fever, cough, rhinorrhea, nasal congestion, sore throat, headache, and myalgias. Ericson, K., & Werner, S. (2012)

Covid-19 has a different impact on people in different ways. When a patient falls ill due to Covid-19 he or she may develop mild to moderate illness and in most cases, it is observed that the patient recovers from it without hospitalization. (Int., 2019) The most common symptoms that are observed in Covid 19 are fever, dry cough, and tiredness. The symptoms that are less common but present in Covid-19 patients are aches and pains, sore throat, diarrhea, conjunctivitis, headache, loss of taste or smell, a rash on the skin, or discoloration of fingers or

toes. In case if the patient has difficulty breathing or shortness of breath, chest pain or pressure, loss of speech or movement then these are the signs of the serious symptoms of the Covid-19.

Croup is a viral condition that causes swelling around the vocal cords. (Croup: Causes, Symptoms, and Diagnosis - Healthline, n.d.) In these breathing difficulties and a bad cough that sounds like a barking seal. It is majorly caused by the viruses that are responsible for the common cold. It is generally active in the months of winter and the croup usually targets children under the age of 5. These are some rare causes of croup allergies, exposure to inhaled irritants, or bacterial infections. Symptoms tend to be most severe in children under the age of 3 since a child's respiratory system is smaller than an adult's. Symptoms that are common in most cases of croup include cold symptoms like sneezing and runny nose, fever, barking cough, heavy breathing, and hoarse voice. Immediate medical care is required in case of a child's ability to breathe. These include symptoms like high-pitched sounds when breathing, difficulty swallowing, and blue or gray skin coloring around the nose, mouth, and fingernails. Croup that persists longer than one week, reoccurs frequently, or is accompanied by a fever higher than 103.5 degrees comes under serious symptoms and immediate concern of the doctor is required.

Dickinson et.al (2021) One of the most frequently diagnosed genetic diseases is **cystic fibrosis** (CF). Progressive obstructive pulmonary disease, sinusitis, exocrine pancreatic insufficiency leading to malabsorption and malnutrition, liver and pancreatic dysfunction, and male infertility are all clinical features. The symptoms include fever, rapid breathing, cough, shortness of breath, and wheezing. Even though CF is a disease that shortens life, survival has improved to median age of 46.2 years as a result of early diagnosis through regular newborn screening, the adoption of evidence-based recommendations to enhance nutritional and pulmonary health, and the establishment of CF-specific interdisciplinary treatment centers.

Gavioli et.al (2021) The authors hope to identify the latest combination of CFTR modulators' safety issues, including notable safety concerns and guidelines for drug-drug interactions. Modulators of the **cystic fibrosis** transmembrane conductance regulator (CFTR) have increased clinical outcomes and lengthened the lives of cystic fibrosis (CF) patients. As CF patients live longer, they are more likely to experience adverse drug reactions from polypharmacy and CFTR

modulators. When compared to placebo, transmembrane conductance regulators for cystic fibrosis are usually well-tolerated with low discontinuation rates. The most serious safety issues are elevated liver enzymes and drug-drug reactions.

Lafond et.al (2021) The impact of **influenza** illness is significant, particularly among young children, the elderly, and those with underlying medical conditions. Improved global estimates for influenza-related hospitalizations and deaths are currently being established. There are still gaps in our understanding of the role of influenza viruses in severe respiratory disease and hospitalizations in adults, particularly in low-income areas. The author can better understand influenza's global effects by estimating its disease prevalence across various target populations and comparing it to other causes of morbidity and mortality. As the world's population ages, the importance of immunizing adults, especially the elderly, is likely to grow.

Jennings et.al (2018) The use of trivalent **influenza** vaccines, which include two influenza A virus subtypes and one of the two circulating influenza type B lineages, is a key component of influenza prevention strategies (Yamagata or Victoria). In several countries, including those in the Asia-Pacific region, mismatches between the vaccine B lineage and the circulating lineage have been reported regularly. Influenza has been identified as a major cause of morbidity in the Asia-Pacific region, affecting people of all ages. In any given season/year, influenza B was detected and linked to between 0% and 92 percent of laboratory-confirmed influenza cases in all 15 countries. Kids aged 1 to 10 years old tended to be more susceptible to influenza type B than children of other ages.

Lung cancer is the type of cancer that begins in the Lungs and it is the 3rd most common cancer in the world. People who usually smoke have the highest risk of having this cancer. In this cancer, the cell divides continuously until it grows into a tumor. (Ranchod, 2021; "Lung cancer - Symptoms and causes", 2021). Alberg & Samet (2003) pointed out that it is leading cancer and the main cause of death in the United States. Cancer can lead to death among both males and females however Males were found to be having higher chances of developing cancer than females. The older people who have been exposed to tobacco smoking actively or passively have more risk of becoming a patient of this disease.

The study by Cooley (2000) reported that Lung cancer patients were mostly suffering from fatigue, pain, loss of appetite, coughing, and insomnia. Older Aged patients were found out to be having shortness of breath and even chest pain compared to younger patients. The study discusses major differences in symptoms among the patients based on age, gender, level of disease. The patients in later stages of the disease have more probability of having symptoms of coughing blood,, however, this symptom is usually not associated with a particular stage.

Lung occupational diseases are occupational lung conditions that are usually work-related. Diseases such as Asthma, industrial bronchitis, COPD, interstitial lung diseases, infections, and even lung cancer are part of this. ("Occupational lung disease - Wikipedia", 2021)

Many times the occupational lung diseases could be misdiagnosed as nonoccupational diseases. (Tarlo, 2012; Vlahovich, Sood, 2020) The prolonged exposure in some industries causes occupational Asthma which can cause coughing, sneezing and even chest pain sometimes. Lung diseases which are also part of occupational diseases can be caused by exposure to radiation or some kind of chemicals or metal and fibers. Lung cancer can lead to chest pain, coughing blood to even shortness of breath. Hypersensitivity Pneumonitis which is usually found in gamers, metal, sugarcane worker, animal or mushroom worker and even swimming pool attendant. Here most exposures are organic, however, the long exposures to fungi or protozoa can cause dry cough, progressive dyspnea, and often significant weight loss. The examination usually results in decreased chest expansion and crackles in basals. (Tarlo, 2012)

Pertussis, also called whooping cough, is a respiratory infection strongly contagious in nature. The disease usually starts with cold-like symptoms and maybe a mild cough or fever. In babies, the cough can be minimal or not even there. Babies may have a symptom known as “apnea.” Apnea is a pause in the child’s breathing pattern. Pertussis is most dangerous for babies. About half of babies younger than 1 year who get the disease need care in the hospital. Fortunately, there is a vaccine available to prevent it.

Pertussis in its early stages appears to be nothing more than the common cold. Therefore, healthcare professionals often do not suspect or diagnose it until the more severe symptoms appear.(Giovannia Gabutti et al, 2014)

Pneumonia is an infection that affects air sacs in the lungs by inflaming them. The primary symptoms are coughing with phlegm or pus, fever, chills, and difficulty breathing. Pneumonia can range in seriousness from mild to life-threatening. It is most serious for infants and young children, people older than age 65, and people with health problems or weakened immune systems. Many germs can cause pneumonia. The most common are bacteria and viruses in the air we breathe. Your body usually prevents these germs from infecting your lungs. But sometimes these germs can overpower your immune system, even if your health is generally good.

Rhinosinusitis is a medical condition that causes the nasal and sinus cavities to get inflamed. Sinusitis alone refers to the inflammation of the sinus cavity. In most cases though, it is almost certainly accompanied by an inflammation of the nasal cs as well, thus leading to 'Rhinosinusitis' (Lund, 1993).

Many types of Rhinosinusitis can affect humans based on the interval of effect (Lanza, D. C., & Kennedy, D. W, 1997). Acute rhinosinusitis is a condition in which the symptoms of the disease last less than 3 months and can get cured just through medication. There are two types of acute rhinosinusitis, either viral or bacterial, and the infection can range from mild to complicated. Recurrent Acute Rhinosinusitis is the condition when a patient experiences issues with acute rhinosinusitis more than 4 times in a single year. Chronic Rhinosinusitis is the condition when a patient shows symptoms of rhinosinusitis for more than 12 weeks at once. This is the most serious condition of Rhinosinusitis that can occur.

In cases of both acute and recurrent acute rhinosinusitis, the symptoms range from simple congestion or obstruction of the nasal cavity, pain in the jaws/teeth or face muscles, a runny nose, migraines/headaches, and in some cases, cough. Other symptoms that might appear are fever, pain, fatigue, pressure in the ears, and hyposmia. In the case of Chronic Rhinosinusitis, symptoms can vary in the ones mentioned above but a necessary presence of either congestion in

the nose, pain or pressure in the face, or loss of smell/cough is required for a diagnosis (Meltzer et al., 2004).

Tuberculosis, commonly known as TB is a bacterial infection that primarily affects the lungs. It spreads by air when the infected person coughs or talks or sneezes nearby. The bacteria that causes the infection is known as Mycobacterium Tuberculosis. The methods of diagnosis for Tuberculosis include blood tests, x-rays, skin tests, etc. It must be paid immediate attention to and treatment is a must to keep the infection from turning too serious (World Health Organization, 2013). The most common symptoms of the presence of TB in the lungs may be a persistent cough that lasts ~3 weeks or more, loss of appetite, loss of weight, blood/mucus in cough, weakness/fatigue, night sweats, and fever (Harding, 2020). Tuberculosis can be treated with relevant medication over the course of time and proper medical attention must be sought.

3. Methodology

After collecting the data about all these diseases and their symptoms, we will build our expert system based on this knowledge. We need to specify the symptoms for different diseases such that they can be used in a proper way to ask valid questions from the users. To solve this issue we use a Decision Tree on discrete classes. Based on the Literature review we have selected the following 16 respiratory diseases for our diagnosis.

1. Acute bronchitis
2. Asthma
3. Bronchiectasis
4. Bronchiolitis
5. Chronic Obstructive Pulmonary Disease (COPD)
6. Common cold
7. COVID-19
8. Croup
9. Cystic fibrosis
10. Influenza
11. Lung cancer

12. Occupational lung diseases
13. Pertussis
14. Pneumonia
15. Rhinosinusitis
16. Tuberculosis

To classify the user into these categories, we have the following 9 factors which are utilized in the form of questions.

- Clinical based factors
    - Smoking history
    - Chest pain
    - Cough
    - Coughing up blood
    - Fever
    - Rapid breathing
    - Rapid heartbeat (Tachycardia)
    - Shortness of breath (dyspnea)
    - Wheezing

Using this scheme and the data collected, we build a decision tree using the ID3 (Iterative Dichotomiser 3). This decision tree can be converted into a set of rules trying to classify each type of disease (or a set of diseases) as a path from the root of the decision tree to as a deciding node. The decision tree generated from the data collected is provided in Fig - 1.

Here have primarily used the Clinical factors in the extraction of the decision tree and thus the rules. The main reason for this is these Clinical factors are the primary indicators of a particular respiratory disease. Although Smoking is not a symptom still it is an indicator causing some respiratory diseases.

The Expert system to interact with the user is built on the knowledge rules provided by the decision tree. First of all, we ask the user their name. Then a series of questions are asked to the user based on the decision tree and the path taken for asking questions is based on the

response the user gives for each question. This is continued until the expert system has enough data to classify the user symptoms to any of the mentioned diseases. If the expert system has that user has covid-19, then more covid related questions are asked to the user to decide on the severity of the issue. We calculate a weighted average score of chances that the user has covid. This score is calculated based on the following factors.

1. Rapid breathing (weight = 2)
2. Chest pain (weight = 2)
3. Sore throat (weight = 1)
4. Loss of taste and smell (weight = 1)
5. Tiredness (Loss of speech and movement) (weight = 2)

After adding the score of each factor (1 if present and 0 if not) by weighting or multiplying by their weights, we get the score. If this score is > 75% we say that there is a very high chance that the user has Covid.

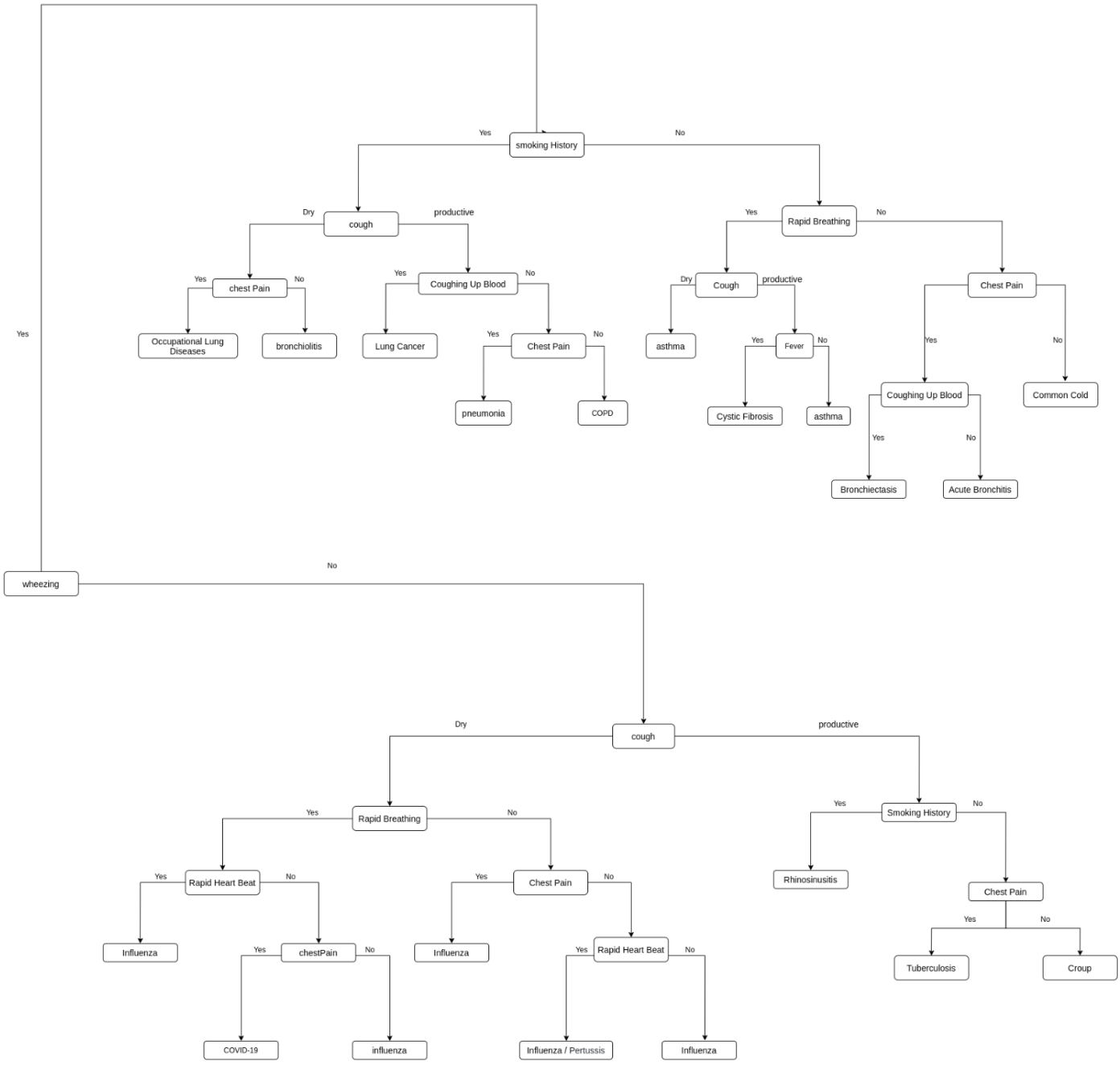


Fig-1: Decision Tree based on disease symptoms

4. Finding & Interpretation

An expert system has been designed in python based on a decision tree calculated from the dataset. The questions asked in the expert system to the users dynamically according to their response to analyzing their situation. These questions are as follows:

Question 1. Do you smoke or does anyone in your family smoke?
Smoking increases your risk of lung disease by damaging your airways and the small air sacs (alveoli) found in your lungs.

Question 2. Do you feel chest pain?
The possible causes of chest pain may be lung-related.

Question 3. Do you cough?
Coughing is one of the symptoms of many respiratory diseases.

Question 4. Do you cough up blood?
The condition of coughing up blood (or Hemoptysis) indicates airway bleeding and may be caused by many different respiratory diseases such as tuberculosis or pneumonia.

Question 5: Do you have a fever?
The CDC (Centers for Disease Control and Prevention) considers a person to have a fever when he or she has a measured temperature of 100.4°F (38°C).

Question 6: Do you experience rapid breathing?
In adult humans at rest, any respiratory rate between 12 and 20 breaths is normal and tachypnea is indicated by a rate greater than 20 breaths per minute.

Question 7: Do you experience shortness of breath?
Shortness of breath (or dyspnea) is often described as an intense tightening in the chest, air hunger, difficulty breathing, breathlessness, or a feeling of suffocation.

Question 8: Do you experience rapid heartbeat?

Tachycardia is the medical term for a heart rate of over 100 beats per minute.

Question 9: Do you experience wheezing?

Wheezing is a high-pitched whistling sound made while you breathe.

Question 10: How long do your symptoms last?

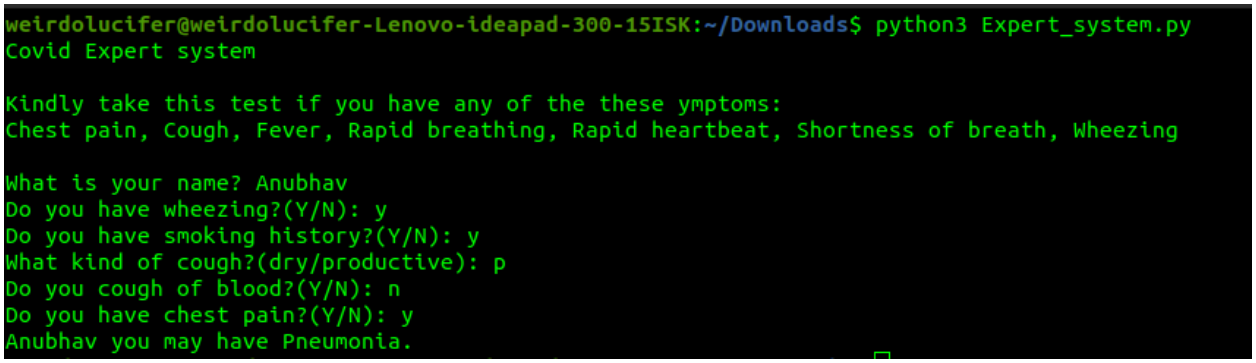
Symptoms of some respiratory diseases like COVID 19 can last for months.

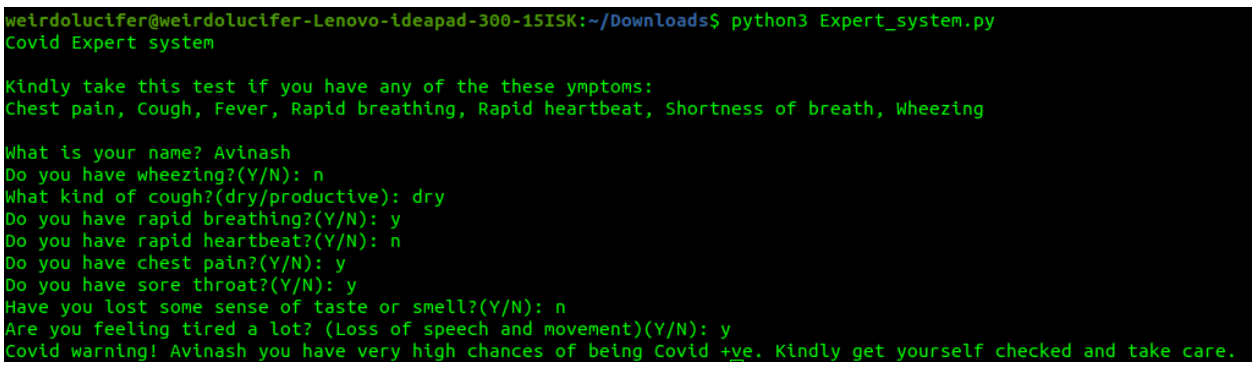
In the case of COVID 19 symptoms, we need more information rather than considered factors to suggest the level of infection:

For Mild Symptoms: Sore throat, Loss of taste or smell

For Severe Symptoms: chest pain, shortness of breath, Tiredness (Loss of speech and movement)

Here are the samples of expert system:





5. Managerial Implications

The expert system will collect the user data based on the questions and collects the data. Then the data will be compared and analyzed based on the parameters we have set and will give the results of whether the user is having any issue or not and if having any then the severity of it is mild or severe. The system will take the inputs and record all the personal information, health, and clinical information of the user. The questionnaire design is based on the decision tree of the system like what kind of issue the user is facing and based on that proceedings questions will be asked. Our system has the ability to detect 16 types of lungs diseases and when the user starts answering the questions the system will put the questions based on the initial information he/she has entered and accordingly the further questions will be asked to detect what kind of symptoms the user is having by comparing to our predefined metric based the answers of those questions and after comparing the answers the system will be able to tell what probable diseases the user is having and can go for further treatment accordingly.

This expert system aims to help companies manage corporate innovation activities successfully while helping the people to get an effective covid detection system. This expert system for covid might be a good framework for establishing a connection between the requirements of people and the medical department. The availability of computerized clinical guidance and an up-to-date knowledge base might play a major role in Indian health organizations, which may not have to constantly train their physician staff and may no longer have to rely on international experts since the expert system can offer clinicians all the information necessary to treat their patients. The study will be helpful for early diagnosis of COVID-19 which will ultimately help in reducing the severe cases. If someone finds the symptoms of COVID-19 in the expert system, one can keep them isolated till the test result comes up. This will help in reducing the number of cases and will reduce the burden form the healthcare personnel.

6. Conclusion

The world is facing a pandemic situation due to COVID-19. A million new cases are coming each day and this leads to a big problem. The death rate is increasing day by day and if a person is finding any symptoms then he/she starts panicking. There is a need for a system that will predict whether the person has got infected by COVID-19 or not based on his symptoms. In this project, with the help of questionnaires, an outline for the system is designed. This system is based on a decision tree that will help in predicting the infection of COVID-19. The decision tree classifier will train on the responses collected in the survey and then this will be combined with the collaborative filtering approach which increases the performance of the covid prediction system. This can help individuals who are facing symptoms to diagnose the disease correctly. Also, the expert system tells if immediate medical attention is needed, which also helps reduce the burden on the hospital infrastructure.

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Contribution details

Headings	Name of Student
Abstract:	Shivanshu
1. Introduction	Obaid Ahmed, Shivanshu
2. Literature Review	All
3. Methodology	Avinash & Anubhav
4. Finding & Interpretation	Avinash & Anubhav
5. Managerial Implications	Shashank, Shivanshu
6. Conclusion	Saurabh, Kiran
7. References	All