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Predictive Formula for COVID-19 Consolidation: Clinical-HRCT Relationship

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ABSTRACT

Background:
COVID-19 pneumonia kills thousands of patients daily, requiring early detection and early intervention. Healthcare systems struggle with the overwhelming number of patients, necessitating an automated method for lung disease measurement in the early stages.
Objective:
To find the relationship between pulmonary HRCT findings and different clinical signs and symptoms of COVID-19 patients.
Methodology:
The study examined 113 COVID-19 patients in four months using a retrospective and cross-sectional approach. Three radiologists independently reviewed HRCT. Data was collected from both genders and age groups. Statistical analysis, such as cross tabulation, logistic regression, Chi-square, and Fisher's exact test, was conducted using SPSS V23 software.
Results:
The study found 70% of patients were over 45 years old, with males being more susceptible to COVID-19. The study examined the relationship between fever, cough, fatigue, myalgia, anosmia, and ageusia with GGOs, consolidation, lung nodules, air bronchogram, crazy paving sign, and pleural effusion using crosstabulation and logistic regression. Results showed significant correlations between these symptoms and consolidation, with 83.2 % accuracy predicted.
Conclusion:
In conclusion, the current study revealed that ground glass opacities and consolidation are typical findings in COVID-19. Significant relationships were found between the primary clinical signs & symptoms and pulmonary HRCT findings. For the prediction of consolidation, the binary logistic regression model is exceptionally good from a clinical aspect.

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KEY WORDS

HRCT, COVID-19, Consolidation. GGO's, Regression.

Introduction

The first case of coronavirus pneumonia was reported in Wuhan, China [1] in the middle of December 2019. On February 11, 2020, it was officially recognized as coronavirus illness 2019 by the World Health Organization (W.H.O.) and as "SARS-CoV-2" by an international classification team. The World Health Organization declared a Public Health Emergency because of the pandemic's quick global spread [2]. Because of the seriousness of this disorder, instances have spread quickly across the globe. According to certain research, one infected patient may result in the infection of more than two additional people [3]. It affects not only the general population but also the health care personnel very badly with this infection and there have been 767,726,861 confirmed cases of COVID-19 as of mid-July 2023, with a death rate of 6,948,764. Due to its unexpected patient outcome and broad transmission, it is the fifth pandemic to be documented in the current era [4].

One worrisome aspect is it's changing variants very frequently, with 12 different types of variants identified worldwide, the three main ones being B.1.1.7, B.1.351, and P.1. These significant variations have quickly risen to the top [5]. It has detrimental effects on the population psychologically, socially, and economically [6]. It has revolutionized the current practice of medicine and introduced an element of infectious illnesses to all fields of medicine. Fever (85%), cough (70%), and shortness of breath (43%), but other symptoms, such as gastrointestinal ones, are also possible or the illness may go unrecognized, are the most typical symptoms of COVID-19. Due to this condition, it is now crucial to detect COVID-19 as soon as possible in order to halt the spread of the disease. First, the gold standard modality is the polymerase chain reaction (PCR), but sensitivity is quite low around 60% and some studies also show that it produces a 30-40% false negative rate [7].

It is also unable to calculate the respiratory decline extent. The capacity of the chest X-ray PA view to identify the early involvement of the lung with COVID-19 infection is limited [8]. HRCT is considered the best modality for diagnosing and accurate findings in COVID-19 patients [9,10] and also plays a vital role in identifying these infectious cases and is suggested as major evidence for diagnosing COVID-19 [11]. Some new research also reported that high-resolution computed tomography has a sensitivity of 90% as compared to polymerase chain reaction. According to the World Health Organization, it is also very useful in diagnosing the severity and progression of the disease. [12] In Pakistan, the first case of coronavirus disease was reported in February 2020, placing Pakistan among the top 20 most affected countries [13]. In countries like Pakistan, it is a very challenging situation due to economic reasons, logistical performance, transporting kits, and collecting samples. Due to these drawbacks, HRCT is performed on COVID-19 patients. It produces high diagnostic and evaluation rates as compared to a polymerase chain reaction and also plays a fundamental role in diagnosing typical imaging characteristics [14] of bilateral ground-glass attenuation, sub-pleural involvement, peripheral distribution, and posterior distribution. [15,16] and it may also lead to crazy paving signs and consolidation bilaterally [17]. Nowadays, HRCT of the chest is widely accessible and used not only for diagnostic purposes but also it is used for the demographic monitoring of coronavirus disease [18].

The signs of the coronavirus disease are very composite and initiate with pyrexia, cough, headache, myalgia, and gastrointestinal symptoms. SARS-CoV-2 includes viruses that range from mild flu to severe Middle East Respiratory Syndrome, also known as MERS. It is very communicable and quickly spreads from one person to another due to the pandemic and direct touch and pulmonary droplets. It may occur at any age, in aged persons, in children, and babies. The aged persons are more prone to effects due to low immunity and co-morbidities such as chronic pulmonary disease, and diabetes at increased risk of illness and its side effects. The risk of many disorders, such as thrombosis, cardiac infarction,

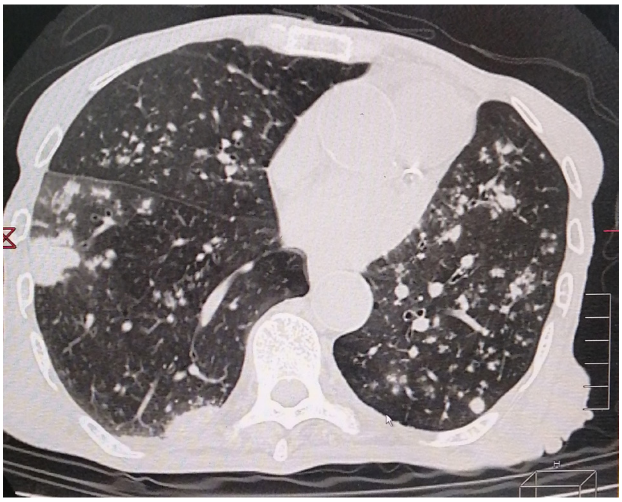


Fig. 1: *An Axial slice of HRCT scan of the chest showing a nodular air space opacity at the anterior segment of the right lower lobe with patches of ground glass haze giving mosaic attenuation involving the right and left lower lobes. Also, there are tree-in-bud opacities in both lobes.*

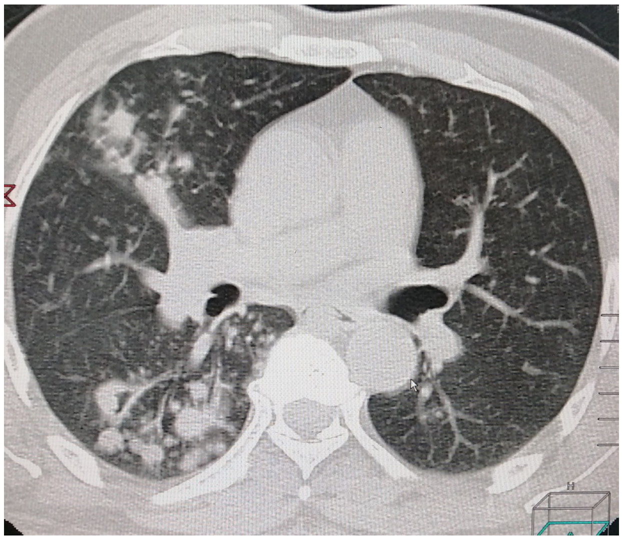


Fig. 2: *An Axial slice of HRCT scan of the chest showing multiple confluent nodular opacities giving tree in bud appearance and some coalescing to form large nodules are seen involving the lateral segment of the right middle lobe and lateral-posterior segment of the right lower lobe*

respiratory acidosis, and hepatocellular carcinoma is also elevated.

Additionally, a small percentage of people may have nausea, vomiting, diarrhea, a runny nose, or nasal congestion. Infection has also been related to severe acute respiratory syndrome, kidney failure, and, in extreme cases, death. In severe cases, patients have dyspnea and hypoxemia around a week after the sickness begins, and they quickly progress to states that are difficult to treat, such as acute respiratory distress syndrome, septic shock, metabolic acidosis, and coagulation dysfunction. Due to unawareness, most people are unaware of the proper characteristic features and symptoms of this disease, in most cases it remains asymptomatic [19] or mildly symptomatic and leads to death, without proper investigation and diagnosis on time.

So, by knowing which clinical symptom is related to which HRCT finding, we diagnose COVID patients more rapidly and without exposing patients to harmful X-rays. So, the current study will help to measure the imaging characteristics of novel coronavirus-infected pneumonia in various age groups and to describe the relationship between clinical and radiological variables for diagnosing COVID-19 pneumonia in early stages with accurate findings thus, it helps to characterize symptomatic and asymptomatic patients to identify lungs condition for further treatment and prevention.

The study aims to measure and establish the correlation between clinical findings and HRCT results of COVID-19 patients by providing a formula for predicting radiological findings based on clinical parameters. By doing so, we want to avoid exposing COVID-19 patients to potentially dangerous radiation, resulting in safer and more effective illness care.

Material And Methods

PATIENTS

This combination of retrospective and cross-sectional study includes the sample size of 113 patients from September 2021 to November 2022, the sample size was taken by finding the mean of the sample size used in previous related articles [20-22].

CT SCANS AND REVIEWS

Toshiba Aquilion 64 Slices CT machine was used. The slice thickness is retained at 3 mm, with a reconstruction interval of 2 mm. Nodule analysis is carried out in the axial plane of the mediastinal window (width: 400 HU, level: 40 HU). The following scanning settings were used: 120 kV tube voltage, 200 mA current, 5 mm spacing, 0.625 mm layer thickness, and a scanning time of

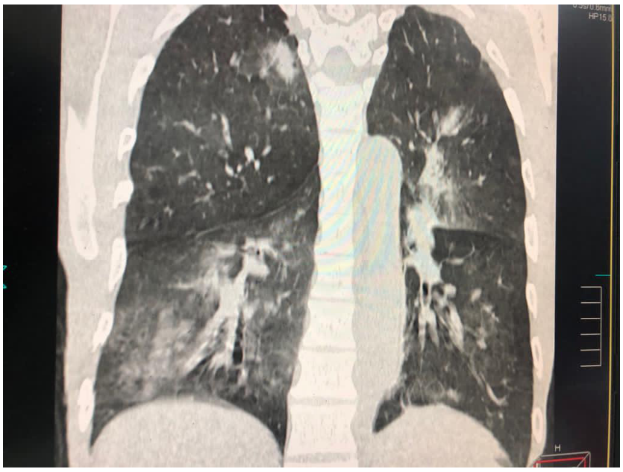


Fig. 3: *Coronal reconstruction of HRCT scan of the chest showing bilateral patchy areas of ground glass haze. Extensive air space lesions are seen involving the anterior segment of the right and left upper lobes with tractional bronchiectasis noted in the lower lobe of the right lung*

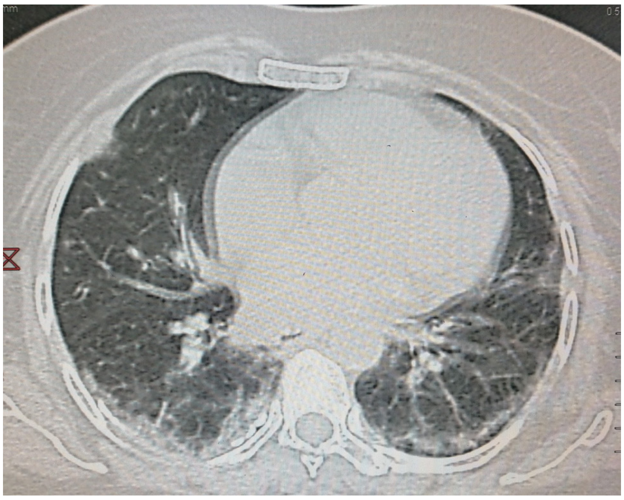


Fig. 4: *An Axial slice of HRCT scan of the chest showing bilateral patchy areas of ground glass haze in lower lobes. The cardiothoracic ratio is raised. Linear band shadows are seen in lateral and posterior segments of bilateral lower lobes with a subtle air space shadow involving the lateral segment of the middle lobe.*

around 5 seconds. The lung window will be 400-600 HU wide, 530-430 HU tall, and 35-40 HU for the mediastinal window. Three trained consultant radiologists with 13-16 years of experience were asked to independently report and assess the HRCT pictures of 19 patients without knowing their clinical details.

ETHICS, CONSENT, AND PERMISSION OF DATA COLLECTION

The University of Lahore's Institutional Review Board approved this study, and all procedures were carried out in compliance with the responsible committee's ethical standards. Patients mostly gave their consent orally.

PCR ASSAYS

To identify COVID-19, pharyngeal swab samples were collected from each patient. These were the exact steps: After placing the throat swab in a collection tube containing 150 mL of virus preservation solution, the respiratory sample RNA isolation kit was used to isolate the total RNA within 2 hours. 40 microliters of cell lysate were placed in a collecting tube and vortexed for 10 seconds. It was centrifuged after being incubated at room temperature for 10 minutes. Real-time polymerase chain reaction was then used to identify the ORF1ab and nucleocapsid protein target genes.

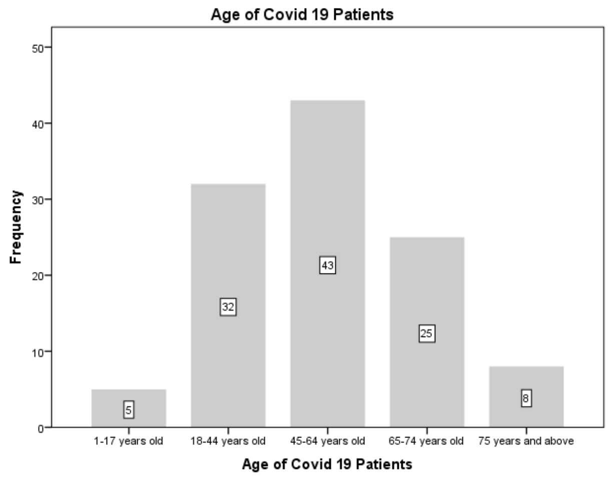
INCLUSION AND EXCLUSION CRITERIA

COVID-19 patients who underwent HRCT in the radiology department and those who were willing to participate in this study were included. Data were collected from both genders and all age groups. Patients who did not want to participate in our study and those who underwent CECT or had other symptomatic problems were excluded.

STATISTICAL ANALYSIS TECHNIQUE

SPSS Version 23 was used for statistical analysis. The data collected was analyzed using cross-tabulation and logistic regression. The research questions were age, gender, radiological findings, and clinical signs & symptoms. Due to the binary nature of the independent variable (Like the presence or absence of cough) and the category or binary nature of the dependent variables (GGO, Consolidation, etc.), logistic regression was chosen as the best analytic technique. 113 patients were included with a history of positive PCR. In a binary logistic regression model, the existence or absence of consolida-

Graph 1: Age of the Covid 19 Patients



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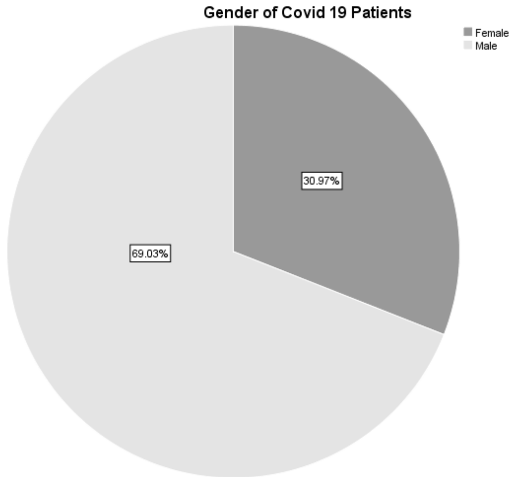

tion served as the dependent variable, while the clinical signs and symptoms status acted as the independent variable. When the model was tested for multicollinearity, there was no evidence of it. The Hosmer-Lemeshow goodness-of-fit test with a significance level of p 0.076 was used to assess the model's fitness.

Results

The study found that in 113 patients the majority of patients (70%) are over 45 years old, with the highest percentage (38.1%) falling in the 45-64 age group. Males (69%) are more susceptible to COVID-19 than females (31%). The common clinical feature of COVID-19 patients is cough (58.4%), followed by anosmia (38.9%), fatigue (30.1%), ageusia (29.2%), fever (31.0%), and myalgia (15.9%). The radiological features observed in COVID-19 patients include Ground Glass Opacities (90.3%), Consolidation (47.8%), Crazy Paving Sign (31.9%), Air Bronchogram (22.1%), Pulmonary Nodules (8.8%), and Pleural Effusion (2.7%) (Figures 1-4). Ground Glass Opacities are the most common radiological feature observed, present in 102 patients, while pleural effusion is the least common radiological feature, present in only 3 patients out of the total 113 patients.

This study also looked at the relationship between fever, cough, fatigue, myalgia, anosmia, ageusia, ground glass opacities, consolidation, lung nodules, air bronchogram, crazy paving sign, and pleural effusion using six crosstabulation tables and logistic regression. On crosstabulation data, Chi-Square and Fisher's Exact tests found significant associations between ground glass opacities and cough. Consolidation of anosmia, myalgia, cough, fever, and ageusia. A strange pavement sign, as well as a fever, cough, and anosmia. An air bronchogram revealed anosmia, cough, and fever. Fatigue, lung nodules, and cough are all symptoms.

Additionally, the logistic regression analysis revealed that consolidation is predicted with 83.2 % accuracy based on these clinical symptoms.

This graph shows the age distribution of covid 19 patients, with the number of patients and corresponding percentages in each age group. The age ranges are broken down into five categories: ages 1 to 17, 18 to 44, 45 to 64, 65 to 74, and ages 75 and above. According to the graph, the 45-64 age group has the highest percentage of covid 19 patients at 38.1%, followed by the 18-44 age group at 28.3%, and the 1-17 age group has the lowest percentage of patients at 4.4%. The graph indicates that the older age groups are more susceptible to COVID-19, as the cumulative percentage of patients over 45 years old represents more than 70% of the total patients.

This graph displays the number of patients and related percentages for each gender in the COVID-19 patient population. It shows that male patients constitute 69.03% of the COVID-19 population, whereas female patients make up 30.97% of the population. The data do not contain missing or ambiguous numbers, as the total proportion of male patients is 100%. According to this graph, men are more affected by COVID-19 than females.

Table 1: This table shows the clinical characteristics

of COVID-19 patients, the number of patients for each clinical characteristic, and whether it is present or not. Clinical signs include fever, coughing, tiredness, myalgia, anosmia (loss of smell), and ageusia (loss of taste). The table shows the number of patients who have each trait and the number of patients who do not. For instance, 35 patients (31.0%) and 78 patients, respectively, do not have fever. Cough is the condition with the greatest prevalence rate (58.4%), then anosmia (38.9%), weariness (30.1%), ageusia (29.2%), fever (31.0%), and myalgia (15.9%). This table shows that cough, reported by 66 individuals, was the most prevalent clinical characteristic among COVID-19 patients in the sample. The least frequent clinical characteristic, myalgia, was only experienced by 18 individuals.

Table 2: The table shows radiological features observed in a group of patients along with their status (absent or present), the number of patients in whom they were observed, and the percentage of patients with the clinical feature. 102 individuals had ground glass opacities, whereas 54, 36, 25, 10, 3, and 3 patients, respectively, had consolidation, crazy pavement sign, air bronchogram, pulmonary nodules, and pleural effusion. Interestingly, Ground Glass Opacities were absent in 11 patients, making it the most common radiological feature in this group of patients. Pleural Effusion was the least common radiological feature observed, present in only 3 patients out of the total 113 patients.

Table 3: The statistical study to ascertain the association between fever and other pulmonary results is shown in the table. Each study contrasted the existence or lack of a particular lung finding with the presence or absence of a fever, and it was conducted using the Chi-Square Test and Fisher's Exact Test. Following the findings, there is no correlation between fever and crazy paving sign (p=0.419), pulmonary nodules (p=0.030), pleural effusion (p=0.551), or ground glass opacities (p=0.017). However, a significant correlation was found between fever and consolidation (p=0.000), as well as between fever and air bronchogram (p=0.000). The findings are statistically significant when the p-value is less than 0.05, which indicates that it is improbable that the observed link just happened by accident.

Table 4: This table presents the statistical analysis used to assess the association between cough and various pulmonary outcomes. The Chi-Square test and Fisher's Exact Test were used in the studies, which compared the presence or absence of cough with a specific pulmonary result.

The findings show a statistical relationship between cough and a variety of patient-reported medical issues as evaluated by several tests. The Chi-square test results show a substantial association between coughing and the presence of the crazy paving sign, air bronchogram, and consolidation (p = 0.000), 0.000, and 0.000, respectively. There is no significant link between a cough and pleural effusion (p = 0.069), however, there is one between a cough and the presence of ground glass opacities and lung nodules (p = 0.030 and 0.001, respectively). The p-values for each test are less than 0.05, indicating that the connections discovered are statistically significant. These findings suggest that coughing may be a useful diagnostic tool for diagnosing medical problems.

Table 5: The table summarizes the statistical study that was conducted to determine the relationship between sleepiness and various pulmonary outcomes. The Chi-Square test and Fisher's Exact Test were used to assess the presence or absence of fatigue with a specific pulmonary outcome. The table illustrates the results of numerous statistical analyses conducted to investigate how weariness related to various radiological findings. The Chi-Square test revealed a significant relationship between weariness and the crazy pavement sign (p=0.047). Fisher's Exact Test results found no significant associations with Pleural Effusion (p=0.215), Ground Glass Opacities (p=1.000), or Consolidation (p=0.258), but did demonstrate a significant relationship between Fatigue and Pulmonary Nodules (p=0.000). The findings imply that radiographic anomalies such as Crazy Paving Sign, Pulmonary Nodules, and Fatigue may be linked.

Table 6: The statistical study to ascertain the association between myalgia and different pulmonary results is shown in the table. The studies evaluated the presence or absence of myalgia with a particular pulmonary result using the Chi-Square Test and Fisher's Exact Test, respectively. The outcomes of the statistical analysis to ascertain the association between myalgia and various radiological abnormalities in COVID-19 patients are shown in the table below. The data were analyzed using Fisher's exact test and the chi-square test. The data revealed a strong correlation between myalgia and both consolidation and the crazy pavement sign (P value =

0.000), suggesting that myalgia patients are more likely to have these radiological characteristics. However, there was no association between myalgia and ground glass opacities, pleural effusion, pulmonary nodules, or air bronchogram (P value > 0.05), indicating that the existence of these radiological abnormalities is not related to myalgia in COVID-19 patients.

Table 7: This table depicts the statistical analysis conducted to assess the relationship between anosmia and other pulmonary outcomes. The Chi-Square Test and Fisher's Exact Test were used to assess the presence or absence of anosmia to a specific lung result. The table below shows the results of statistical studies performed on a sample of 113 people to examine the relationship between anosmia (loss of smell) and various lung imaging findings. Chi-square and Fisher's exact tests were used to assess the connection between anosmia and the presence of crazy paving sign, air bronchogram, lung nodules, pleural effusion, ground glass opacities, and consolidation. There was a statistically significant link between anosmia and the crazy paving sign (p = 0.001) and consolidation (p = 0.000) imaging results, indicating that having anosmia increased the probability of having these imaging findings. However, there was no statistically significant correlation (all p values > 0.05) between anosmia and lung nodules, pleural effusion, or ground glass opacities, showing that anosmia was not associated with these imaging findings in this cohort.

Table 8: The statistical study to ascertain the association between ageusia and other pulmonary results was reported in the table. The studies evaluated the presence or absence of ageusia with a particular pulmonary result using the Chi-Square Test and Fisher's Exact Test, respectively. The findings of statistical tests conducted to ascertain if there is a connection between ageusia (loss of taste) and different imaging characteristics in patients are shown in the table below. Each imaging feature's statistical method, outcomes, p-value, and conclusion are shown in the table. According to the table, there is no association between ageusia and the following conditions: Crazy Paving Sign, Air Bronchogram, Pulmonary Nodules, Pleural Effusion, and Ground Glass Opacities (p-values > 0.05). However, there is a strong correlation (p-value = 0.017) between ageusia and consolidation, suggesting that individuals with ageusia may have a higher likelihood of experiencing consolidation on imaging compared to patients without ageusia.

Table 11: Significant relationships between HRCT and various clinical findings

HRCT Findings	Clinical Findings Related
Ground Glass Opacities	Cough
Consolidation	Anosmia, Myalgia, Cough, Fever, Ageusia
Crazy Paving Sign	Anosmia, Myalgia, Cough, Fever
Air Bronchogram	Anosmia, Cough, Fever,
Pulmonary Nodules	Cough, Fatigue
Pleural Effusion	No Relationship found

Table 11: This table summarizes the relationship between different high-resolution computed tomography (HRCT) findings and clinical symptoms. Ground glass opacities are associated with cough, while consolidation is associated with anosmia, myalgia, cough, fever, and ageusia. The crazy paving sign is also associated with anosmia, myalgia, cough, and fever. Air bronchogram is related to anosmia, cough, and fever. Pulmonary nodules are associated with cough and fatigue. However, no relationship has been found between pleural effusion and any of the listed clinical symptoms.

Logistic Regression

From association findings, we observed that consolidation has a relationship with all clinical symptoms of covid 19 patients.

We applied binary logistic regression for the prediction of consolidation based on clinical symptoms of patients. We use consolidation as the dependent variable and clinical symptoms as independent variables.

The output of logistic regression is given below.

1. The *P-Value* of H&L test is 0.076 which shows that our model is fit for prediction.

Hosmer and Lemeshow Test			
Step	**Chi-Square**	**df**	**Sig.**
1	12.826	7	**0.076**

2. From T2 we observed that the logistic regression model provides an 83.2% overall classification rate for consolidation based on clinical symptoms.

Predicted				
			Consolida-tion	**Per-centage**
Observed		**Absent**	**Present**	**Correct**
Consoli-dation	**Absent**	53	06	89.8 %
	Present	13	41	75.9%
Overall Percentage				**83.2%**

3. We drive this equation from variables.

Variables in the Equation						
	B	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
Factor 1	-2.093	0.407	26.455	1	0.000	0.123
Factor 2	0.445	0.334	1.778	1	0.182	1.561
Constant	12.343	3.138	15.470	1	0.000	229457.680

From the above table, we can write the equation of logistic regression e.g.

Factor 1

Factor 1 is a composite score that takes into account whether four COVID-19 symptoms fever, cough, fatigue, and myalgia are present or absent. A value of 1 indicates that the individual has the presence of one symptom, while a value of 2 indicates the absence of one symptom. In factor 1 we will write the sum of all four values that we will get from these four symptoms.

Symptom	If present then represent with	If absent then represent with
Fever	1	2
Cough	1	2
Fatigue	1	2
Myalgia	1	2

Factor 2:

Factor 2 is a composite score that combines information about the presence or absence of two covid 19 symptoms, including anosmia and ageusia. A value of 1 indicates that the individual has the presence of one symptom, while a value of 2 indicates the absence of one symptom. In factor 2 we will write the sum of all four values that we will get from these two symptoms.

Symptom	If present then represent with	If absent then represent with
Anosmia	1	2
Ageusia	1	2

We used the sigmoid function for calculating the probability of consolidation.

$$P = \frac{1}{1 + e^{-y}}$$

The output of the above sigmoid function gives the probability of consolidation based on clinical symptoms.

So, with the proposed binary logistic regression model we can predict consolidation based on clinical symptoms.

Discussion

COVID-19 appears to be a brand-new illness affecting individuals that is mostly spread by contact with droplets. Although it is unknown how the novel coronavirus spreads, it has been found in nasopharyngeal swabs, sputum, lower respiratory secretions, blood, and other samples. Early detection and treatment are critical for reducing the occurrence and death of severe cases. Adult patients constituted the majority of the study's participants, and there was no appreciable difference in the number of male and female patients. The most prevalent clinical signs are cough, anosmia, fever, fatigue, ageusia, and myalgia. This is comparable to other coronavirus varieties.

The current study shows significant relationships between the primary clinical complaints and the pulmonary HRCT findings. Our findings revealed that chest CT played a significant role in clinical practice and might be used to assess the severity of the condition. The most frequent abnormality identified by CT characteristics was GGO, which was followed by consolidation. This is consistent with the findings of the most recent research released [23-25].

According to recommendations from the World Health Organization and the Centers for Disease Control and Prevention, during the prevalence of SARS, CT and chest radiography were the primary diagnostic tools. Specialists in these fields identified three major abnormalities in COVID-19 patients using high-resolution computed tomography (HRCT) of the chest: Ground Glass Opacities, Consolidation, and pleural effusion. Therefore, they concluded that HRCT is the optimal diagnostic tool for diagnosing and assessing the severity of lung conditions, aiding frontline workers in managing the situation [2, 26].

Wei Zhao et al. conducted a study in 2020 in which around 101 confirmed patients with coronavirus disease underwent HRCT Chest. The purpose of this study was to examine the correlation between clinical symptoms of COVID-19 pneumonia and chest CT scans. COVID-19 pneumonia exhibited typical imaging characteristics, with ground glass opacities being more frequent (87%) according to the data. Patients of advanced age are more affected than those of younger age. As a result, it is determined that the majority of patients with covid 19 pneumonia, the lesion exhibits ground glass opacities, consolidation, and vascular expansion, and the findings of this study are also comparable to those of other studies.

Rui Han et al. conducted a study in 2020 with 108 patients to assess the clinical and computed tomography symptoms of coronavirus disease. Data from COVID cases with PCR confirmation revealed that 87% of patients had fever, 60% had a dry cough, 39% had fatigue, 60% had ground-glass opacity, and 41% had GGO with consolidation. Low to midgrade fever, dry cough, and exhaustion are clinical indicators of COVID-19 pneumonia, as is patchy GGO with or without consolidation affecting many lobes, as well as halo sign, vascular thickening, crazy paving pattern, or air bronchogram sign. The new study's findings are likewise compatible with this investigation [27].

In the year 2020 research was carried out by Jiong Wu et al. in which 80 confirmed cases of COVID-19 were taken and their data was reviewed & this study aimed to evaluate the relationship between radiological findings and clinical features. The findings showed that interlobular septal thickness (59%), consolidation (63%), and ground glass opacity (91%), were the most common CT abnormalities. Additionally, 76% of the patients had high temperatures, and 73% of the patients' experienced coughs. They concluded that there are strong correlations between computed tomography findings, primary clinical symptoms, and laboratory findings, indicating that the results of this research are consistent with those of recent studies [28].

The research was conducted by Arshed Hussain Parry et al. in 2020, the frequency of the results was most common age group is 49 years old patients group and males are more prone to get covid 19 and ground glass opacities are seen in 100% of patients, Crazy paving sign in 32.6 %, Consolidation in 47.2%, and air bronchogram in 24.7% of patients, fever (26.2%), cough (9%), fatigue (4.8%) and myalgia (4.9 %), so, the current study findings are also consistent with this research [29].

Many previous studies showed relatable results with the frequencies of current study results and in this pilot study, we used logistic regression to find the relationship between clinical findings and HRCT findings of COVID-19 patients, in this study our sample consisted of 113 participants, with 54 individuals having a consolidation. Our analysis revealed that clinical signs and symptoms were a significant predictor of consolidation.

From our results, we discover the equation of logistic regression with 83.2 % accuracy and *P-Value* of H&L test is 0.076 which shows that our model is fit for prediction of consolidation based on clinical signs and symptoms.

Y=12.343-2.093(Factor 1)+0.445(Factor 2)

Factor 1 represents the sum of four symptoms fever, cough, fatigue, and myalgia, where the presence of each symptom is represented with a "1" and the absence of each symptom is represented with a "2". e.g., If a patient is presented with fever and myalgia than in factor 1, we will write 6, or if a patient will represent with fever, cough and myalgia than we will write 5 in factor 1.

Factor 2 represents the sum of two symptoms anosmia and ageusia, where the presence of each symptom is represented with a "1" and the absence of each symptom is represented with a "2". e.g., If a patient is presented with anosmia then in factor 2, we will write 3, or if a patient will represent with anosmia and ageusia than we will write 2 in factor 2.

After this, we will use a sigmoid function to calculate the probability of consolidation.

$$\boldsymbol{P = \frac{1}{1 + e^{-y}}}$$

In this sigmoid function represents the exponential function with a negative exponent of y, where ***e*** is the mathematical constant approximately equal to 2.71828. The output of this sigmoid function will give us the probability of consolidation based on clinical symptoms. So, with the proposed binary logistic regression model, we can predict consolidation from clinical symptoms.

According to this research, clinical signs and symptoms may be crucial factor to take into account in studies looking at the results of HRCT. It's critical to acknowledge the limitations of this pilot research. First, the limited sample size may restrict the applicability of our results. Furthermore, additional possibly significant factors were not taken into consideration in our study. Overall, our pilot study using logistic regression suggests that clinical signs & symptoms may be an important predictor of HRCT findings, but further research is needed to confirm and expand upon these findings.

Conclusion

In conclusion, the current study revealed that ground glass opacities and consolidation are typical findings in covid 19. Significant relationships were found between the primary clinical signs & symptoms and pulmonary HRCT findings. For the prediction of consolidation, the binary logistic regression model is exceptionally good from a clinical aspect. **R**

Table 1: Frequencies of Clinical Features			
Clinical Feature	**Status**	**No. of Patients**	**Percentage of present clinical feature**
Fever	Present	35	**31.0 %**
	Absent	78	
Cough	Present	66	**58.4 %**
	Absent	47	
Fatigue	Present	34	**30.1 %**
	Absent	79	
Myalgia	Present	18	**15.9 %**
	Absent	95	
Anosmia	Present	44	**38.9 %**
	Absent	69	
Ageusia	Present	33	**29.2 %**
	Absent	80	

Table 2: Frequencies of Radiological Features			
Radiological Feature	**Status**	**No. of Patients**	**Percentage of present clinical feature**
Ground Glass Opacities	Absent	11	**90.3 %**
	Present	102	
Consolidation	Absent	59	**47.8 %**
	Present	54	
Crazy Paving Sign	Absent	77	**31.9 %**
	Present	36	
Air Bronchogram	Absent	88	**22.1 %**
	Present	25	
Pulmonary Nodules	Absent	103	**8.8 %**
	Present	10	
Pleural Effusion	Absent	110	**2.7 %**
	Present	3	

Table 3: Crosstabulation between fever and various pulmonary findings.

Variable	Statistical Technique	Results					P Value	Conclusion
Fever* Crazy Paving Sign	Chi Square Test	Crosstab					0.419	There is no relationship Between Fever & Crazy Paving Sign.
		Crazy Paving Sign						
				Absent	Present	Total		
		Fever	Present	22	13	35		
			Absent	55	23	78		
		Total		77	36	113		
Fever* Air Bronchogram	Chi Square Test	Crosstab					0.000	There is relationship Between Fever & Air Bronchogram
		Air Bronchogram						
				Absent	Present	Total		
		Fever	Present	11	24	35		
			Absent	77	01	78		
		Total		88	25	113		
Fever* Pulmonary Nodules	Fisher's Exact Test	Crosstab					0.030	There is relationship Between Fever & Pulmonary Nodules.
		Pulmonary Nodules						
				Absent	Present	Total		
		Fever	Present	35	0	35		
			Absent	68	10	78		
		Total		103	10	113		
Fever*Pleural Effusion	Fisher's Exact Test	Crosstab					0.551	There is no relationship Between Fever & Pleural Effusion.
		Pleural Effusion						
				Absent	Present	Total		
		Fever	Present	11	24	35		
			Absent	77	01	78		
		Total		88	25	113		
Fever*Ground Glass Opacities	Fisher's Exact Test	Crosstab					0.01	There is no relationship Between Fever & Ground Glass Opacities.
		Ground Glass Opacities						
				Absent	Present	Total		
		Fever	Present	0	35	35		
			Absent	11	67	78		
		Total		11	102	113		
Fever*Consolidation	Chi Square Test	Crosstab					0.000	There is relationship Between Fever & Consolidation.
		Consolidation						
				Absent	Present	Total		
		Fever	Present	6	29	35		
			Absent	53	25	78		
		Total		59	54	113		

<table>
<tr><th colspan="9">Table 4: Crosstabulation between cough and various pulmonary findings.</th></tr>
<tr><th>Variable</th><th>Statistical Technique</th><th colspan="5">Results</th><th>P Value</th><th>Conclusion</th></tr>
<tr><td rowspan="6">Cough* Crazy Paving Sign</td><td rowspan="6">Chi Square Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.000</td><td rowspan="6">There is relationship Between Cough & Crazy Paving Sign.</td></tr>
<tr><td colspan="5">Crazy Paving Sign</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Cough</td><td>Present</td><td>31</td><td>35</td><td>66</td></tr>
<tr><td>Absent</td><td>46</td><td>1</td><td>47</td></tr>
<tr><td colspan="2">Total</td><td>77</td><td>36</td><td>113</td></tr>
<tr><td rowspan="6">Cough* Air Bronchogram</td><td rowspan="6">Chi Square Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.000</td><td rowspan="6">There is relationship Between Cough & Air Bronchogram</td></tr>
<tr><td colspan="5">Air Bronchogram</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Cough</td><td>Present</td><td>41</td><td>25</td><td>66</td></tr>
<tr><td>Absent</td><td>47</td><td>0</td><td>47</td></tr>
<tr><td colspan="2">Total</td><td>88</td><td>25</td><td>113</td></tr>
<tr><td rowspan="6">Cough* Pulmonary Nodules</td><td rowspan="6">Fisher's Exact Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.030</td><td rowspan="6">There is relationship Between Cough & Pulmonary Nodules.</td></tr>
<tr><td colspan="5">Pulmonary Nodules</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Cough</td><td>Present</td><td>66</td><td>0</td><td>66</td></tr>
<tr><td>Absent</td><td>37</td><td>10</td><td>47</td></tr>
<tr><td colspan="2">Total</td><td>103</td><td>10</td><td>113</td></tr>
<tr><td rowspan="6">Cough*Pleural Effusion</td><td rowspan="6">Fisher's Exact Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.069</td><td rowspan="6">There is no relationship Between Cough & Pleural Effusion.</td></tr>
<tr><td colspan="5">Pleural Effusion</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Cough</td><td>Present</td><td>66</td><td>0</td><td>66</td></tr>
<tr><td>Absent</td><td>44</td><td>03</td><td>47</td></tr>
<tr><td colspan="2">Total</td><td>110</td><td>03</td><td>113</td></tr>
<tr><td rowspan="7">Cough*Ground Glass Opacities</td><td rowspan="7">Fisher's Exact Test</td><td colspan="5">Crosstab</td><td rowspan="7">0.001</td><td rowspan="7">There is relationship Between Cough & Ground Glass Opacities.</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Ground Glass Opacities</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Cough</td><td>Present</td><td>1</td><td>65</td><td>66</td></tr>
<tr><td>Absent</td><td>10</td><td>37</td><td>47</td></tr>
<tr><td colspan="2">Total</td><td>11</td><td>102</td><td>113</td></tr>
<tr><td rowspan="6">Cough*Consolidation</td><td rowspan="6">Chi Square Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.000</td><td rowspan="6">There is relationship Between Cough & Consolidation.</td></tr>
<tr><td colspan="5">Consolidation</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td>Present</td><td>Total</td></tr>
<tr><td rowspan="2">Cough</td><td>Present</td><td>22</td><td>44</td><td>66</td></tr>
<tr><td>Absent</td><td>37</td><td>10</td><td>47</td></tr>
<tr><td colspan="2">Total</td><td>59</td><td>54</td><td>113</td></tr>
</table>

Table 5: Crosstabulation between fatigue and various pulmonary findings.

Variable	Statistical Technique	Results					P Value	Conclusion
Fatigue* Crazy Paving Sign	Chi Square Test	Crosstab					0.047	There is relationship Between Fatigue & Crazy Paving Sign.
		Crazy Paving Sign						
				Absent		Total		
		Fatigue	Present	28	06	34		
			Absent	49	30	79		
		Total		77	36	113		
Fatigue* Air Bronchogram	Chi Square Test	Crosstab					0.469	There is no relationship Between Fatigue & Air Bronchogram
		Air Bronchogram						
				Absent		Total		
		Fatigue	Present	25	9	34		
			Absent	63	16	79		
		Total		88	25	113		
Fatigue* Pulmonary Nodules	Fisher's Exact Test	Crosstab					0.000	There is relationship Between Fatigue & Pulmonary Nodules.
		Pulmonary Nodules						
				Absent		Total		
		Fatigue	Present	24	10	34		
			Absent	79	0	79		
		Total		103	10	113		
Fatigue*Pleural Effusion	Fisher's Exact Test	Crosstab					0.215	There is no relationship Between Fatigue & Pleural Effusion.
		Pleural Effusion						
				Absent		Total		
		Fatigue	Present	32	02	34		
			Absent	78	01	79		
		Total		110	03	113		
Fatigue*Ground Glass Opacities	Fisher's Exact Test	Crosstab					1.000	There is no relationship Between Fatigue & Ground Glass Opacities.
		Ground Glass Opacities						
				Absent		Total		
		Fatigue	Present	3	31	34		
			Absent	8	71	79		
		Total		11	102	113		
Fatigue*Consolidation	Chi Square Test	Crosstab					0.258	There is no relationship Between Fatigue & Consolidation.
		Consolidation						
				Absent	Present	Total		
		Fatigue	Present	15	19	34		
			Absent	44	35	79		
		Total		59	54	113		

<table>
<tr><th colspan="9">Table 6: Crosstabulation between myalgia and various pulmonary findings.</th></tr>
<tr><th>Variable</th><th>Statistical Technique</th><th colspan="5">Results</th><th>P Value</th><th>Conclusion</th></tr>
<tr><td rowspan="6">Myalgia* Crazy Paving Sign</td><td rowspan="6">Chi Square Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.000</td><td rowspan="6">There is relationship Between Myalgia & Crazy Paving Sign.</td></tr>
<tr><td colspan="5">Crazy Paving Sign</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Myalgia</td><td>Present</td><td>0</td><td>18</td><td>18</td></tr>
<tr><td>Absent</td><td>77</td><td>18</td><td>95</td></tr>
<tr><td colspan="2">Total</td><td>77</td><td>36</td><td>113</td></tr>
<tr><td rowspan="6">Myalgia* Air Bronchogram</td><td rowspan="6">Fisher's Exact Test</td><td colspan="5">Crosstab</td><td rowspan="6">1.000</td><td rowspan="6">There is no relationship Between Myalgia & Air Bronchogram</td></tr>
<tr><td colspan="5">Air Bronchogram</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Myalgia</td><td>Present</td><td>14</td><td>4</td><td>18</td></tr>
<tr><td>Absent</td><td>74</td><td>21</td><td>95</td></tr>
<tr><td colspan="2">Total</td><td>88</td><td>25</td><td>113</td></tr>
<tr><td rowspan="6">Myalgia* Pulmonary Nodules</td><td rowspan="6">Fisher's Exact Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.360</td><td rowspan="6">There is no relationship Between Myalgia & Pulmonary Nodules.</td></tr>
<tr><td colspan="5">Pulmonary Nodules</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Myalgia</td><td>Present</td><td>18</td><td>0</td><td>18</td></tr>
<tr><td>Absent</td><td>85</td><td>10</td><td>95</td></tr>
<tr><td colspan="2">Total</td><td>103</td><td>10</td><td>113</td></tr>
<tr><td rowspan="6">Myalgia*Pleural Effusion</td><td rowspan="6">Fisher's Exact Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.409</td><td rowspan="6">There is no relationship Between Myalgia & Pleural Effusion.</td></tr>
<tr><td colspan="5">Pleural Effusion</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Myalgia</td><td>Present</td><td>17</td><td>1</td><td>18</td></tr>
<tr><td>Absent</td><td>93</td><td>2</td><td>95</td></tr>
<tr><td colspan="2">Total</td><td>110</td><td>03</td><td>113</td></tr>
<tr><td rowspan="6">Myalgia*Ground Glass Opacities</td><td rowspan="6">Fisher's Exact Test</td><td colspan="5">Crosstab</td><td rowspan="6">1.000</td><td rowspan="6">There is no relationship Between Myalgia & Ground Glass Opacities.</td></tr>
<tr><td colspan="5">Ground Glass Opacities</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td></td><td>Total</td></tr>
<tr><td rowspan="2">Myalgia</td><td>Present</td><td>1</td><td>17</td><td>18</td></tr>
<tr><td>Absent</td><td>10</td><td>85</td><td>95</td></tr>
<tr><td colspan="2">Total</td><td>11</td><td>102</td><td>113</td></tr>
<tr><td rowspan="6">Myalgia*Consolidation</td><td rowspan="6">Chi Square Test</td><td colspan="5">Crosstab</td><td rowspan="6">0.000</td><td rowspan="6">There is relationship Between Myalgia & Consolidation.</td></tr>
<tr><td colspan="5">Consolidation</td></tr>
<tr><td colspan="2"></td><td>Absent</td><td>Present</td><td>Total</td></tr>
<tr><td rowspan="2">Myalgia</td><td>Present</td><td>0</td><td>18</td><td>18</td></tr>
<tr><td>Absent</td><td>59</td><td>36</td><td>95</td></tr>
<tr><td colspan="2">Total</td><td>59</td><td>54</td><td>113</td></tr>
</table>

Table 7: Crosstabulation between anosmia and various pulmonary findings.								
Variable	**Statistical Technique**	**Results**					**P Value**	**Conclusion**
Anosmia* Crazy Paving Sign	Chi Square Test	Crosstab					0.001	There is relationship Between Anosmia & Crazy Paving Sign.
		Crazy Paving Sign						
				Absent		Total		
		Anosmia	Present	38	06	44		
			Absent	39	30	69		
		Total		77	36	113		
Anosmia* Air Bronchogram	Chi Square Test	Crosstab					0.002	There is relationship Between Anosmia & Air Bronchogram
		Air Bronchogram						
				Absent		Total		
		Anosmia	Present	41	3	44		
			Absent	47	22	69		
		Total		88	25	113		
Anosmia* Pulmonary Nodules	Fisher's Exact Test	Crosstab					1.000	There is no relationship Between Anosmia & Pulmonary Nodules.
		Pulmonary Nodules						
				Absent		Total		
		Anosmia	Present	40	4	44		
			Absent	63	6	69		
		Total		103	10	113		
Anosmia*Pleural Effusion	Fisher's Exact Test	Crosstab					0.280	There is no relationship Between Anosmia & Pleural Effusion.
		Pleural Effusion						
				Absent		Total		
		Anosmia	Present	44	0	44		
			Absent	66	3	69		
		Total		110	3	113		
Anosmia*Ground Glass Opacities	Fisher's Exact Test	Crosstab					1.000	There is no relationship Between Anosmia & Ground Glass Opacities.
		Ground Glass Opacities						
				Absent		Total		
		Anosmia	Present	04	40	44		
			Absent	07	62	69		
		Total		11	102	113		
Anosmia*Consolidation	Chi Square Test	Crosstab					0.000	There is relationship Between Anosmia & Consolidation.
		Consolidation						
				Absent	Present	Total		
		Anosmia	Present	33	11	44		
			Absent	26	43	69		
		Total		59	54	113		

Table 8: Crosstabulation between ageusia and various pulmonary findings.

Variable	Statistical Technique	Results					P Value	Conclusion
Ageusia* Crazy Paving Sign	Chi Square Test	Crosstab					0.264	There is no relationship Between Ageusia & Crazy Paving Sign.
		Crazy Paving Sign						
				Absent		Total		
		Ageusia	Present	25	08	33		
			Absent	52	28	80		
		Total		77	36	113		
Ageusia* Air Bronchogram	Chi Square Test	Crosstab					0.469	There is no relationship Between Ageusia & Air Bronchogram
		Air Bronchogram						
				Absent		Total		
		Ageusia	Present	29	4	33		
			Absent	59	21	80		
		Total		88	25	113		
Ageusia* Pulmonary Nodules	Fisher's Exact Test	Crosstab					0.153	There is no relationship Between Ageusia & Pulmonary Nodules.
		Pulmonary Nodules						
				Absent		Total		
		Ageusia	Present	28	5	33		
			Absent	75	5	80		
		Total		103	10	113		
Ageusia*Pleural Effusion	Fisher's Exact Test	Crosstab					0.555	There is no relationship Between Ageusia & Pleural Effusion.
		Pleural Effusion						
				Absent		Total		
		Ageusia	Present	33	0	33		
			Absent	77	03	80		
		Total		110	03	113		
Ageusia*Ground Glass Opacities	Fisher's Exact Test	Crosstab					1.000	There is no relationship Between Ageusia & Ground Glass Opacities.
		Ground Glass Opacities						
				Absent		Total		
		Ageusia	Present	03	30	33		
			Absent	08	72	80		
		Total		11	102	113		
Ageusia*Consolidation	Chi Square Test	Crosstab					0.017	There is relationship Between Ageusia & Consolidation.
		Consolidation						
				Absent	Present	Total		
		Ageusia	Present	23	10	33		
			Absent	36	44	80		
		Total		59	54	113		

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