**ADDIS ABABA UNIVERSITY**

**COLLEGE OF HEALTH SCIENCES**

**SCHOOL OF MEDICINE**

**DEPARTMENT OF RADIOLOGY**

# THE SENSITIVITY OF CHEST CT FOR THE DIAGNOSIS OF COVID-19 PNEUMONIA AND IMAGING PATTERNS AS SEEN ON CHEST CT A CROSSECTIONAL PROSPECTIVE STUDY DONE IN ADDIS ABABA

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A RESEARCH REPORT FOR PREPARATION OF SENIOR PAPER TO BE SUBMITTED TO THE RADIOLOGY DEPARTMENT, COLLEGE OF HEALTH SCIENCE, ADDIS ABABA UNIVERSITY IN PREPARATION FOR PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE POSTGRADUATE STUDY IN RADIOLOGY

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The sensitivity of chest CT for the diagnosis of Covid-19 pneumonia and imaging patterns as seen on chest CT a crossectional prospective study done in Addis Ababa

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## ABBREVIATIONS

| | |
|---|---|
| ACE | Angiotensin-converting enzyme |
| ARDS | Acute respiratory distress syndrome |
| CDC | Center for disease control |
| CO-RADs | COVID 19 reporting and data system |
| CT | Computed Tomography |
| DM | Diabetes Mellitus |
| GGO | Ground glass opacity |
| MS Excel | Microsoft Excel |
| PACS | Picture archiving and communication system |
| PPV | Positive predictive value |
| RNA | Ribonucleic Acid |
| RT- PCR | Reverse-transcription polymerase chain reaction |
| SPSS | Statistical Package for the Social Sciences |
| TASH | Tikur Anbessa specialized hospital |
| US | Ultrasound |
| WHO | World Health Organization |

# Contents

## Abstract

### Background:

Coronavirus disease 2019 (COVID-19) is a respiratory illness caused by a novel coronavirus designated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] The infection widely and rapidly spread all over the world with significant impacts upon the sociopolitical milieu and healthcare delivery systems. On 11 March 2020 COVID-19 was declared a pandemic by WHO [2]and on March 13, 2020, the first confirmed COVID-19 case was reported in Ethiopia. The clinical presentation spectrum varies and includes mild to moderate symptoms, severe symptoms, and critical illness.[2] Although RT PCR test has been considered to be the gold standard, chest imaging especially has an adjunct role not only in the diagnosis but in the assessment of the severity of the disease and identification of complications.[3] Identification of the typical imaging pattern and degree of involvement is important to guide and plan treatment.

**Objective**: The study was conducted to assess the sensitivity of chest CT scan as compared to the standard RT PCR for the diagnosis of COVID-19 and also to determine the different chest CT imaging patterns and severity of COVID-19 pneumonia.

**Method**: A crossectional study was conducted based on data collected from different diagnostic centers and treatment centers from July 1, 2021, to October 1, 2021. The chest CT of the patients was reviewed and a structured questionnaire was filled on a Google form sheet. The data were exported and analyzed on SPSS version 26.

**Result:** Among a total of 193 patients included in this study, 116 (60.1%) were males and 77 (39.9%) were females with a mean (SD) age of 50±14.2 years. Among patients for whom data regarding previously known comorbidities was available hypertension and diabetes mellitus accounted for 26 (61.9%), and 25 (59.5%) respectively. Of 107 patients whose presenting complaints were available, cough was the most common complaint seen in 82 (76%) of the patients, followed by shortness of breath in 65 (60.7%), chest pain in 36 (33.6%), and fatigue in 26 (24.3%). Using the RT PCR result as a gold standard the sensitivity, and specificity of chest CT were found to be 82.9 % and 16.7% respectively. The chest CT distribution showed that 95.9% of the cases were bilateral and 51.3 % had a peripheral distribution. Among the typical chest CT

patterns, 157(83%) of the CT images showed GGO, 152(80.4%) consolidation, and 68(35.4%) showed broncho-vascular thickening.

The mean chest CT severity score was 13.6±6.2 and 95 (49.2%) patients had a score of >18 (severe). A positive correlation was identified between CT severity score with age and diabetes with a P-value < 0.01.

**Conclusion:** This study demonstrated that chest CT has a high sensitivity (82.9%) in the diagnosis of COVID-19 pneumonia. Ground glass opacity, consolidation, and bronchovascular thickening were the predominant features seen with a predominant bilateral, basal, and peripheral distribution. The study also revealed chest CT severity score is positively correlated with age and comorbidity of DM.

Keywords: COVID-19, chest CT, RT-PCR, Cross-sectional study

# Introduction

## Background

Coronavirus disease 2019 (COVID-19) is an illness caused by a novel coronavirus designated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) which was first identified amid an outbreak of respiratory illness cases in Wuhan City, Hubei Province, China in December 2019. [1]

Coronaviruses are non-segmented enveloped RNA viruses with a single-strand linear positive-sense RNA. Six types of coronavirus have been identified that cause human disease. Four of these cause mild respiratory symptoms whereas the other two, Middle East Respiratory Syndrome (MERS-CoV) coronavirus and Severe Acute Respiratory Syndrome coronavirus (SARS-CoV-1), have previously resulted in epidemics with high mortality rates. [2] Respiratory illness is the most commonly associated manifestation of SARS-CoV-2. This is due to abundant ACE2 receptor expression in the lung parenchyma, specifically on the acinar side of lung epithelial cells (pneumocytes) within the alveolar spaces, allowing virus entry. [2]

After a coronavirus was identified as the cause of a cluster of pneumonia cases in Wuhan city, it rapidly spread, resulting in an epidemic throughout China. (4) On January 30, 2020, WHO declared a global public health emergency against the outbreak of COVID-19, and on March 11, 2020, WHO stated that coronavirus is a global pandemic. (5)

The main mode of transmission of the virus is person to person. The transmission is thought to occur mainly through respiratory droplets that are released in a cough or sneeze or during a conversation. Environmental contamination also plays a role in viral transmission and occurs through droplet accumulation on frequently touched surfaces, with subsequent spread to susceptible mucous membranes within the mouth, nose, and eyes. [2, 3]

The clinical presentation spectrum varies and includes mild to moderate symptoms (80%), severe symptoms (14%–15%), and critical illness (5%). The most common symptoms at presentation are fever, cough, and shortness of breath. Mild to moderate disease is generally characterized by

constitutional symptoms and the possible development of mild pneumonia, while symptoms of severe disease include dyspnea and hypoxia. [2, 3]

The SARS-CoV-2 virus has the potential to cause complications in every organ system in the body. ARDS is a major complication of severe COVID-19, seen in 20%–40% of patients with severe symptoms. Other complications include cardiac complications including arrhythmias (including atrial fibrillation), acute myocarditis, cardiomyopathy, and shock. Thromboembolic phenomena can also occur including pulmonary embolism (PE), peripheral venous and arterial thrombosis, and acute stroke. [2]

Reverse-transcription polymerase chain reaction (RT-PCR) tests are currently the gold standard diagnostic tool for COVID-19. RT-PCR assays are performed on nasopharyngeal and/or oropharyngeal swabs**.** (3)This test may obtain false-negative results owing to a variety of factors, including insufficient viral load, improper collection of viral samples, and technical errors during the swabbing procedure. [2,6]

The role of chest imaging is as an adjunct in cases of an initial negative RT-PCR test with persistent high clinical suspicion for disease and for diagnosis in patients with worsening symptoms or those in an environment that is resource-constrained, concerning RT-PCR testing availability. The American College of Radiology also advises against using CT as a first-line tool in the diagnosis of COVID-19, recommending that it be used sparingly and reserved for symptomatic hospitalized patients with specific clinical indications, such as assessment of complications. [2]

Among pulmonary imaging, chest radiography is a less sensitive modality for the detection of COVID-19 lung disease when compared with that of CT, with a reported baseline chest radiography sensitivity of 69 %. [2,6]

Pulmonary ultrasound is another imaging modality that is useful in the evaluation of critically ill patients with COVID-19, as it can be performed at the bedside and allows detection of pneumonia and complications like pneumothorax. [2]

CT has been an important imaging modality in the diagnosis and management of patients with viral pneumonia, as demonstrated in the large-scale outbreaks in Severe Acute Respiratory Syndrome (SARS-CoV) and Middle East Respiratory Syndrome (MERS-CoV**).** [7]

The primary chest CT finding in patients with COVID-19 pneumonia was ground-glass opacity (GGO), crazy-paving, consolidation, bronchovascular thickening, and traction bronchiectasis. The ground-glass and/or consolidative opacities are usually bilateral, peripheral, and basal in distribution were considered to be suggestive. Mediastinal lymphadenopathy, pleural effusions pulmonary nodules, tree-in-bud, pneumothorax, cavitation, atoll sign, pneumo-mediastinum were considered to be atypical for covid pneumonia. [8]

## STATEMENT OF THE PROBLEM AND SIGNIFICANCE OF THE STUDY

While RT-PCR is considered the gold standard for definitive diagnosis, there are limitations to its availability, sensitivity for detection of COVID-19, and extended waiting times for results. Furthermore, inter-operator variability could also affect the quality of samples obtained and result in a false negative. [9]

CT has become a standard of care in the diagnosis and assessment of a variety of respiratory conditions, such as interstitial lung disease and lung cancer, and optimizes the management process. Although CT scans are not routinely used to diagnose ARDS, certain complications that appear relating to mechanical ventilation, including pneumonia, pneumothorax, and emphysema, are sometimes identified by CT but not on chest radiography(3)

Chest CT is a rapid and cost-effective alternative to RT-PCR and in conjunction with high clinical suspicion, confers a highly specific diagnosis for COVID-19. [9] In patients with high clinical suspicion and repeated negative RT-PCR tests, chest CT will help for early diagnosis, patient isolation, and contact tracing. A significant number of patients with the typical imaging feature were also diagnosed incidentally where imaging is done for other indications. [10][6]

Imaging is also beneficial in differentiating patients with COVID-19 pneumonia from others with infectious and noninfectious pulmonary pathologies with an acute presentation. [10]

The significance of this study, in general, is for assessing the diagnostic capacity of chest imaging especially chest CT in the diagnosis of COVID-19 pneumonia by identifying the sensitivity as compared to RT-PCR and the typical chest imaging patterns.

## LITERATURE REVIEW

Ever since the initial outbreak of COVID-19, the virus spread at a significant rate increasingly affecting a large number of people all over the world which overburdened the global health system. [11] According to WHO as of October 2, 2021, globally more than 235 million cases and 4.8 million deaths were recorded, and in Ethiopia, there were more than 347 thousand cases and 5675 deaths.

The highly contagious nature of the virus contributed to the fast rate of infection over a short period. According to CDC and WHO, early detection of both symptomatic and asymptomatic potentially infectious individuals is crucial in the prevention of disease transmission and control of the fast spread of the infection. [10]

The COVID-19 virus infects people of all ages. However, the evidence to date shows that two groups of people are at higher risk for developing COVID-19. One group of these people are older people and the other group has people with underlying medical conditions. [12–14] In a crossectional study done in Tehran from February 24, 2020 to March 24, 2020, the highest incidence of the disease was within the age group of 50–59 years, while the lowest rate was in the 0–9 years age group. The highest rate of positive samples in terms of COVID-19 among suspected individuals was for patients >80 years of age (89%) and the highest mortality rate was in the age range of 70–79 years (31%) and >80 years (30%) respectively. [13] Data regarding the gender-based differences in COVID-19 suggests that male patients are at risk of developing severe illness and increased mortality due to COVID-19 compared to female patients. [14]

On a cross-sectional study conducted in Karachi, Pakistan, from May 1 to July 30, 2020 including 212 patients, the most common comorbidities were uncontrolled diabetes with hypertension (n = 56; 26.4%), controlled diabetes (n = 22; 10.37%), obstructive airway disease (n = 16; 7.5%), and interstitial lung disease (n = 14; 6.6%). A total of 48 (22.64%) patients had no comorbidities.[15]

The clinical spectrum of COVID-19 varies from asymptomatic or paucisymptomatic forms to clinical illness characterized by acute respiratory failure requiring mechanical ventilation, septic shock, and multiple organ failure. It is estimated that 17.9% to 33.3% of infected patients will remain asymptomatic. Stokes et al. reported that among 373,883 confirmed symptomatic COVID-19 cases in the US, 70% experienced fever, cough, shortness of breath, 36% reported myalgia, and

34% reported headache(14). One study done in China on 1099 patients with laboratory-confirmed COVID-19 from 552 hospitals admitted as of January 29, 2020, the study showed that the median age of the patients was 47 years and 41.9% of the patients were female. The most common symptoms were fever 43.8% on admission and cough (67.8%). Gastrointestinal symptoms were uncommon (3.8%). [(16)] In a prospective study done in Rome, Italy from March 4 to March 19, 2020, which enrolled 158 consecutive participants (83 Male, 75 Female), fever was observed in 97 (61%), and cough and dyspnea were present in 88 (56%) and 52 (33%), respectively. [(17)]

The presumed gold standard diagnostic method, RT PCR, has variable sensitivity of about 63 % from nasal swabs and 32% from oropharyngeal swabs with a specificity ranging from 85-100%. [(1)] Radiological examinations, especially chest computed tomography (CT), play an important complementary role in the early diagnosis and management. Recent emerging studies have reported that the sensitivity of chest CT may be greater than RT-PCR. (3) Standard radiographic examination (X-ray) of the chest has a low sensitivity in identifying early lung changes; it can be completely normal in the initial stages of the disease.

In one study done in China from January 6 to February 6, a total of 1049 patients with suspected COVID-19 who underwent chest CT and laboratory virus nucleic acid testing (RT-PCR assay with throat swab samples) were retrospectively enrolled into the study. Of the 1014 eligible patients, 601 had positive RT-PCR results and 413 had negative RT-PCR results, for a positive rate of 59%. Of the 601 Patients with positive RT-PCR results, 580 (97%) had positive chest CT scans and of the 413 patients with negative RT-PCR results, 308 (75%) had positive chest CT scans. Using RT-PCR results as the reference standard, the researchers concluded that the sensitivity, specificity, and accuracy of chest CT in indicating COVID-19 infection were 97%, 25 %, and 68% respectively. [(18)]

In another study done during the peak of the Italian COVID-19 epidemic, From March 4th to April 9th, 2020, a series of 773 patients that underwent both non-contrast chest CT and RT-PCR with a time interval no longer than a week due to suspected SARS-CoV-2 infection were enrolled to the study. On the study RT-PCR testing showed an overall positive rate of 59.8 % and the chest CT sensitivity, specificity and accuracy was determined to be 90.7%, 78.8%, and 85.9% respectively[(19)]

In a study conducted in Paris, France to evaluate the diagnostic and prognostic performance of CT in patients with COVID19 suspicion depending on symptoms and date of onset from March 1st to March 28th, 214 patients having both chest CT scan and reverse transcriptase-polymerase chain reaction (RT- PCT) within 24 h were retrospectively evaluated. Of the 214 patients, 129 had at least one positive RT-PCR result. Sensitivity, specificity, negative and positive predictive values of chest CT were 81%, 91%, 76%, and 93% respectively based on a reading by experts and considering the 123 patients with symptoms for more than 5 days, the corresponding figures were 93 %, 88 %, 86 % and 94 % concluding that chest CT has a higher sensitivity for the diagnosis and sensitivity increased after 5 days of symptoms. [20]

A meta-analysis, which included six studies comprising a total of 1431 patients who were mainly symptomatic and at high risk for COVID-19, the reported a chest CT pooled sensitivity of 94.6% (95% CI: 91.9%, 96.4%) and a pooled specificity of 46.0% (95% CI: 31.9%, 60.7%) in the detection of COVID-19[21]

Several studies were also conducted to assess the imaging patterns of COVID-19 pneumonia. In one study done in China on 1099 patients, of 975 CT scans that were performed at the time of admission, 86.2% revealed abnormal results. The most common patterns on chest CT were ground-glass opacity (56.4%) and bilateral patchy shadowing (51.8%). No radiographic or CT abnormality was found in 157 of 877 patients (17.9%) with non-severe disease and 5 of 173 patients (2.9%) with severe disease. [16]

Identification of the typical imaging pattern of COVID-19 pneumonia helps to differentiate it from other atypical bacterial and viral pneumonia. Several studies were done to identify the typical and atypical imagining features of COVID-19.

On a prospective study done on Rome, Italy with RT-PCR serving as the reference standard, sensitivity, specificity, and accuracy of CT for COVID-19 pneumonia were reported to be 97%, 56%, and 72 % respectively. In the subgroup of 58 participants with positive RT-PCR and CT findings, ground-glass opacities were present in all 58 (100%), both multi-lobe and posterior involvement were present in 54 (93%), bilateral pneumonia was present in 53 (91%), and subsegmental vessel enlargement (.3 mm) was present in 52 (89%). [17]

In a retrospective study conducted in Henan China from January 9 to February 26, 2020, to determine the chest CT features among patients with coronavirus, 56 RT PCR confirmed cases underwent chest CT. Among these patients, forty patients (83.6%) had two or more opacities in the lung, eighteen (23.7%) had only GGO, twenty-nine patients (52.7%) had ground-glass opacity and eight patients (14.5) had only consolidation. A total of 43 patients (78.2%) showed two or more lobe involvement. The distribution tends to be peripheral and central in 54.5% and purely peripheral in 45.5%. Fifty patients (90.9%) had a lower lobe involvement. (22)

In a similar retrospective study done in Wuhan China from January 4 to February 3, 2020, a total of 108 patients with mild COVID-19 pneumonia (38 men, 70 women; age range, 21–90 years; mean, 45 years) were enrolled in the study. The time from onset of symptoms to CT examination was 1–3 days (median, 1 day). The clinical manifestations were fever in 94 of 108 (87%) patients, dry cough in 65 (60%), and fatigue in 42 (39%). The distribution of involved lobes was one lobe in 38 (35%) patients, two or three lobes in 24 (22%), and four or five lobes in 46 (43%). The major involvement was peripheral (97 patients [90%]), and the common lesion shape was patchy (93 patients [86%]). Sixty-five (60%) patients had ground-glass opacity (GGO), and 44 (41%) had GGO with consolidation. Vascular thickening (86 patients [80%]), crazy paving pattern (43 patients [40%]), air bronchogram sign (52 patients [48%]), and halo sign (69 [64%]) were also observed in this study. The study concluded that the early CT findings are patchy GGO with or without consolidation involving multiple lobes, mainly in the peripheral zone, accompanied by halo sign, vascular thickening, crazy paving pattern, or air bronchograms sign. (23)

In another retrospective study done from four centers in China from January 18, 2020, to February 2, 2020, chest CT scans from 121 symptomatic patients infected with coronavirus disease 2019 (COVID-19) were reviewed for common CT findings with the time between symptom onset and the initial CT scan. Of the 121 patients, 27 (22%) had no ground-glass opacities and no consolidation on chest CT scans. Of the 94 patients with ground-glass opacities, consolidation, or both, 41 (34%) had only ground-glass opacities (with no consolidation) and two (2%) had consolidation in the absence of ground-glass opacities. Eighteen patients (15%) had opacities in one lobe, 14 (12%) had two affected lobes, 11 (9%) had three affected lobes, 18 (15%) had four affected lobes, and 33 (27%) had disease affecting all five lobes. In terms of distribution of disease in the axial plane, peripheral distribution was found in eight of the 36 patients imaged in the early

phase (22%), 21 of the 33 patients imaged in the intermediate phase (64%), and 18 of the 25 patients imaged in the late phase (72%). (24)

Literature published by reviewing different publications and case reports, a total of 919 patients were included in the final review. After combining the available data, the study found the characteristic patterns and distribution of CT manifestations: ground-glass opacification (GGO) (88.0%), bilateral involvement (87.5%), peripheral distribution (76.0%), and multilobar (more than one lobe) involvement (78.8%). (25)

Jin et al. described the characteristic CT findings of COVID-19 in five temporal stages as ultra-early, early, rapid progression, consolidation, and dissipation stages. During the ultra-early stage (asymptomatic, 1–2 weeks after exposure), CT may show single or multiple focal GGO, patchy consolidative opacities, pulmonary nodules encircled by GGO, and air bronchograms. In the early stage (early symptomatic presentation, 54% of their cases), CT findings include single or multiple GGOs, or GGO combined with interlobular septal thickening. In the rapid progression stage (days 3–7 of symptomatic presentation), CT findings include large, light consolidative opacities and air bronchograms. During the consolidation stage (second week of symptomatic presentation), reductions in density and size of the consolidative opacities may be seen. About 2–3 weeks after the onset, CT may show dispersed patchy consolidative opacities, reticular opacities (referred to as “strip-like opacities”), bronchial wall thickening, and interlobular septal thickening. (26)

A retrospective study was done in a tertiary hospital in Turkey to investigate the use of the COVID-19 Reporting and Data System (CO-RADS) classification enrolled 280 hospitalized patients diagnosed with COVID-19 pneumonia into the study. Of the total participants, 111 (39.6%) had positive real-time reverse transcriptase-polymerase chain reaction (RT-PCR) results. CO-RADS 5 group patients had statistically significant positive RT-PCR results than the other groups ($P < 0.001$). All of the CO-RADS 2 group patients (30) had negative RT-PCR results. (27)

From March 6 to March 22, 2020, 130 symptomatic SARS-CoV-2 patients were enrolled for a center analysis, and chest CT examinations were retrospectively evaluated. In all cases, a semi-quantitative CT severity scoring proposed was calculated per each of the 5 lobes considering the extent of anatomic involvement, as follows: 0, no involvement; 1, < 5% involvement; 2, 5–25% involvement; 3, 26–50% involvement; 4, 51–75% involvement; and 5, > 75% involvement. The

resulting global CT score was the sum of each lobar score and (0 to 25). (28) Pathological involvement was most common in the inferior lobes, right lower lobe (RLL) in 122 patients (93.8%), and left lower lobe (LLL) in 123 patients (94.6%). The mean global CT score was 12.3 ± 11.1. (28)

# OBJECTIVES

## GENERAL OBJECTIVE

- To assess the sensitivity of chest CT, describe imaging patterns and imaging severity score of COVID pneumonia
- To assess the demographic distribution, comorbidities and clinical presentation of patients with COVID pneumonia

## SPECIFIC OBJECTIVES

- To assess the demographic distribution of patients imaged for COVID-19
- To assess the common clinical presentation and comorbidities of patients who are subjected to chest CT
- To identify the typical and atypical chest CT patterns of COVID pneumonia
- To assess the correlation of demographic factors and comorbidity to the severity of COVID-19 pneumonia

# METHODS AND MATERIALS

## Operational definitions

**Clinically suspicious case**: A patient who presented with acute upper or lower respiratory symptoms with or without fever or having close contact with a confirmed COVID-19 patient [(9)]

**Suspicious imaging feature:** A patient with chest CT feature of consolidation or GGO with peripheral, bilateral, and basal distribution. [(2)]

**Unrelated illness**: a disease condition that is not attributed to the infection or complication of COVID-19. [(9)]

**CT severity score *(Francone et al, 2020)***

A semi-quantitative CT severity scoring was used to calculate the involvement of the 5 lobes considering the anatomic extent, the involvement of each lobe is scored as follows: 0, no involvement; 1, < 5% involvement; 2, 5–25% involvement; 3, 26–50% involvement; 4, 51–75% involvement; and 5, > 75% involvement. The resulting global CT score will be the sum of each lobar score to be graded between 0 to 25. A score of <7 is considered to be mild, and a score between 8-17 moderate and >18 severe. (28)

## STUDY AREA AND PERIOD

The study was conducted among patients who had a laboratory-confirmed COVID-19 infection or on those having high clinical suspicion and imaged with chest CT to rule out complications. The majority of the patients were admitted to one of the COVID-19 treatment centers where they received inpatient care. The imaging of the study participants was done mainly in two institutions, Pioneer and Wudassie diagnostic centers. Pioneer diagnostic center is one of the biggest imaging facilities in Addis Ababa, which provides a dedicated imaging service for patients with suspected and confirmed COVID-19 using a 128 slice CT scanner. Wudassie diagnostic center also provides imaging services for all referred patients despite their clinical diagnosis. Additional data were also collected from Tikur Anbessa Specialized Hospital (TASH), which is the biggest tertiary hospital in the country with >700 beds and multiple outpatient services. The hospital has an isolation ward and ICU for COVID-19 patients and provides imaging services using two CT scan machines with 128 and 64 slice thicknesses. The treatment centers are dedicated care units that provide inpatient medical services including intensive care services for patients with moderate to severe COVID-19 pneumonia who require admission. The data is collected from > 8 COVID-19 treatment centers in Addis Ababa with a variable number of inpatient beds and services (including Millennium hall treatment center, Eka Kotebe General Hospital, St Peter hospital, Bulbula COVID-19 field hospital, St Paul hospital, Zewditu memorial hospital and Hallelujah hospital). Most of these treatment centers currently don't have a dedicated CT scan for the imaging of their patients and those patients who require crossectional imaging are sent to the diagnostic centers.

Patients who have been admitted to the treatment centers and patients who have been scanned in the aforementioned institutions from July 1, 2021, to October 1 2021 were enrolled in the study.

## STUDY DESIGN

A prospective study was performed to collect data of patients with clinically suspected or confirmed COVID-19 who underwent chest CT imaging and patients imaged for unrelated illness with incidental findings suggestive of COVID-19 pneumonia.

## POPULATION

### SOURCE POPULATION

All patients with clinical suspicion or confirmed COVID-19 infection who underwent chest CT scanning and patients scanned for unrelated illness with imaging suspicion during the study period.

### STUDY POPULATION

All patients with clinical suspicion or confirmed COVID-19 patients who underwent chest CT and patients with suspicious imaging features scanned for unrelated illness and have RT PCR test done during the study period.

## INCLUSION AND EXCLUSION CRITERIA

### INCLUSION CRITERIA

- All patients with clinically suspected or confirmed COVID-19 infection underwent chest CT scan evaluation.

### EXCLUSION CRITERIA

- Patient with suspected COVID-19 pneumonia whose RT PCR test is unknown or lost
- Those patients underwent chest imaging but were not reviewed due to poor quality (artifacts or not completely inclusive of the whole chest)

## SAMPLING TECHNIQUE AND SAMPLE SIZE

All patients with laboratory-confirmed or clinical suspected COVID-19 infection for whom chest CT scanning and RT PCR test were done during the study period (from July 1, 2021, to October 1, 2021) were enrolled in the study.

## DATA COLLECTION INSTRUMENTS, TECHNIQUES, AND DATA COLLECTORS

Chest CTs of patients who fulfilled the inclusion criteria were reviewed using the open-source DICOM viewer. The first few cases were reviewed with the principal investigator and experienced

senior radiologist with cardiothoracic imaging subspecialty to standardize the data collection. Important patient data including the COVID-19 RT-PCR result, the demographic data, and the clinical conditions of the patient including the patient presentation and any underlying illness is collected from patient imaging requests and the national COVID registry.

The Principal Investigator collected the data using a structured questionnaire and exported it to SPSS for analysis.

### Data analysis

The data collected from the Google form questionnaire is exported to SPSS version 26.0 statistical package for analysis after checking for missing values before analysis. Details of data analysis, like tables and graphs, were used to show demographic data, clinical findings, and CT findings and patterns. Pearson correlation was used to look for associations between the demographic variables, clinical characteristics with chest CT findings also an association between severities of the disease. The correlation was considered to be statistical significance at $P< 0.05$ to test any association between variables.

## ETHICAL CONSIDERATIONS

Ethical clearance was obtained from the research and ethics committee of the Department of Radiology and Institutional Review Board of the College of Health Sciences (IRB-CHS) with permission to collect the data obtained. To protect the privacy of the patients involved, patient identifiers were used to keep the anonymity of the study subjects involved in the study.

### Dissemination of results

Results of the study will be submitted to the Department of Radiology at TASH as part of the dissertation requirement for the postgraduate certificate program and will be presented on a seminar prepared by the research committee for all staff and residents in the department. It will also be submitted to medical journals for possible publication.

# Results

## Patient characteristics

In this study, a total of 193 patients were included and among which 116 (60.1%) were males and 77(39.9%) were females. The study included patients with age ranges from 23 to 85 years with a mean age of 50±14.2 years, and the majority of the patients 92(47.7%) were above the age of 51 years.

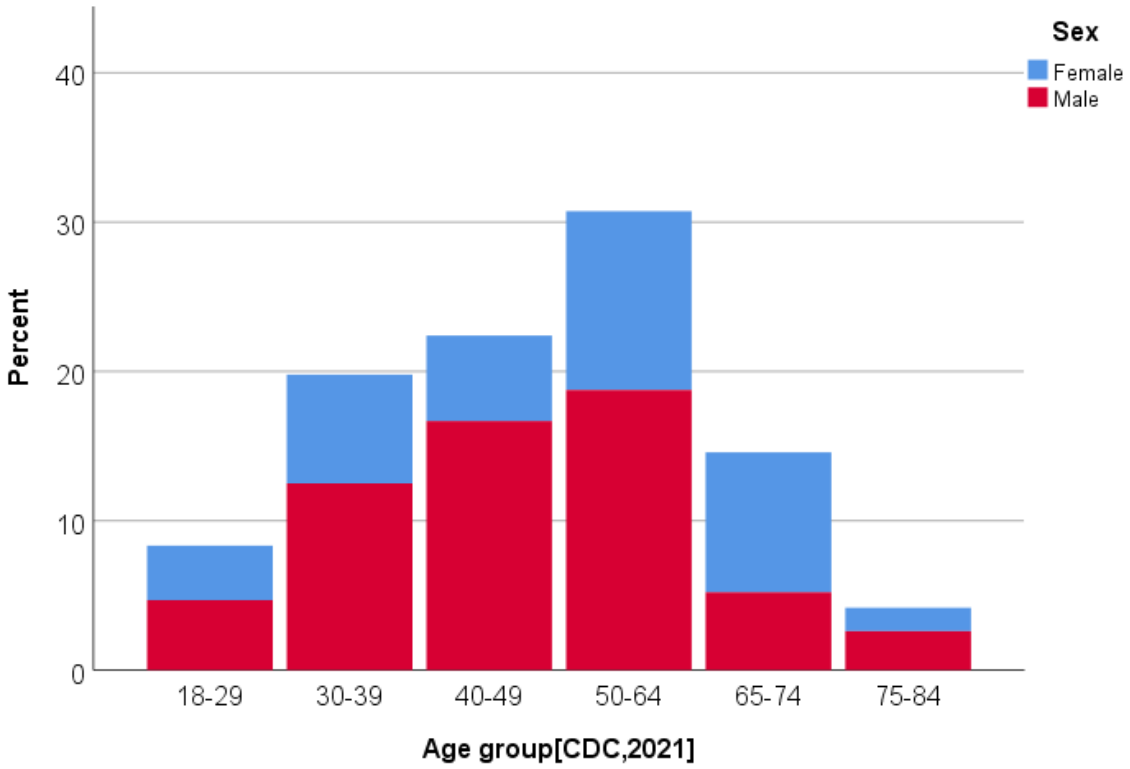



***Figure 1:*** *Bar chart for Age distribution in a number*

Of 193 patients included in the study, only 42(21.8%) had one or more known comorbidity among which 26(61.9%) had hypertension, 25(59.5%) had DM, 4 patients had known HIV/AIDS and two patients had a known lung disease. And from patient with a known comorbidity, a third of the patients[14(33.3%)] had both diabetes and hypertension.

***Table 1:*** *Underlying comorbidities of the patient*

| **Variable (n=42)** | **Number(percent)** | |
|---|---|---|
| Co-morbidity | DM | 25(59.5) |
| | Hypertension | 26(61.9) |
| | HIV/AIDS | 4(9.5) |
| | Underlying lung disease | 2(4.7) |
| | Cardiac disease | 1(2.3) |
| | Malignancy | 1(2.3) |
| | Renal disease | 1(2.3) |

Among the study participants, 84(43.5%) of patients' clinical presentation was known and from those with a known presentation, only a single patient was asymptomatic. Of the symptomatic patients, cough was the most common complaint seen in 82(76%) patients, followed by SOB in 65(60.7%), chest pain in 36(33.6%), and fatigue in 26(24.3%). The duration of symptoms for the majority of symptomatic patients was between 5-8 days 46(43%).

***Table 2:*** *clinical presentation of patients*

| **Variable(n=107)** | **Frequency (percent)** | |
|---|---|---|
| Patients presenting symptoms | Cough | 82(76.6) |
| | SOB | 65(60.7) |
| | Chest pain | 36(33.6) |
| | Fatigue | 26(24.3) |
| | Fever | 20(18.7) |
| | Headache | 14(13) |
| | Arthralgia/myalgia | 4(3.7) |
| | Loss of taste | 4(3.7) |
| | Sore throat | 2(1.9) |
| Duration of symptoms | < 4 days | 19(17.7) |
| | 5-8 days | 46(43) |
| | 9-14 days | 15(14) |
| | >15 days | 28(26.1) |

From the total number of patients included in this study, COVID-19 RT PCT positivity was 93.8% (181). Most of the patients subjected for chest CT evaluation underwent CT angiography 101(52.3%) and 63(32.6 %) patients underwent non-contrast CT and the rest had conventional post-contrast CT. Among the patients who underwent chest CT scans, 190(98.4 %) patients had

positive chest findings and only 3 patients had unremarkable chest CT findings. Considering chest CT finding with CORAD scores of 4 and 5 to be suggestive of COVID-19 infection, 160 patients (82.9%) had a chest CT diagnosis of COVID-19 pneumonia. Using the RT PCR result as a gold standard, the sensitivity, and specificity of chest CT was found to be 82.9 % and 16.7% respectively.

## Chest CT finding, distribution, and severity

In this study, on the chest CT pattern distribution, 95.9% of the cases had bilateral lung involvement, 51.3% had a peripheral distribution and 45.6% had a diffuse distribution. All lobes were involved by the disease process in about 90% of the cases. The anterior-posterior distribution of the chest involvement showed that 64.2% of the cases were diffuse and 34.5% of patients had a predominant dorsal distribution.

The chest CTs findings in this study showed both typical and atypical patterns for COVID-19 pneumonia, with a typical pattern seen in 189(97.9%) patients and atypical features in 30(15.5%). Among patients with typical chest CT patterns, 157(83%) had GGO, 152(80.4%) had consolidation, 68(35.4%) had broncho-vascular thickening, and subpleural curved fibrosis was seen in 67(35.4%) patients. Among patients who presented with overlapping atypical chest CT features, mediastinal lymphadenopathy was seen in 18(60%), pleural effusion in 16(53.3%), and non-specific nodular opacity in 3(10%) patients.

The imaging patterns of symptomatic patients are shown to be variable with the duration of symptoms. Of the patients who had presenting symptoms < 4 days duration, consolidation was found in 18(94.7%) and GGO in 15(78.9%). And from a total of 44 patients who present with symptoms between 5-8 days, 38(86.3%) had GGO, 34(77%) had consolidation, 14(31.8%) bronchovascular thickening, and 15(34%) had curved peripheral fibrosis. Among patients who presented with 9-14 days of symptoms, 14(93.3%) patients had consolidation, 13(86.6%) had GGO, 8(53.3%) with bronchovascular thickening, and 5 patients with curved peripheral fibrosis. Of a total of 28 patients whose presenting symptoms for >15 days, 25(89.3%) had consolidation, 24(85.7%) had GGO, 14(50%) has bronchovascular thickening and 12(42.8%) had curved peripheral fibrosis.

***Table 3****: Imaging patterns of patients*

| **Variable(n=193)** | **Number(percent)** | |
|---|---|---|
| Typical feature(189) | GGO | 157(83) |
| | Consolidation | 152(80.4) |
| | Broncho-vascular thickening | 68(36) |
| | Peripheral curved fibrosis | 67(35.4) |
| | Crazy paving | 10(5.2) |
| | Traction bronchiectasis | 15(7.9) |
| | Halo sign | 14(7.4) |
| Atypical feature(30) | Mediastinal lymphadenopathy | 18(60) |
| | Pleural effusion | 16(53.3) |
| | Nodular opacities | 3(10) |

***Table 4****: Frequency of combined typical imaging feature*

| **Variable(n=193)** | **Number(percent)** |
|---|---|
| GGO and consolidation | 120(62.1) |
| GGO and bronchovascular thickening | 55(28.5) |
| Consolidation and bronchovascular thickening | 55(28.5) |
| GGO, Consolidation and bronchovascular thickening | 44(22.8) |

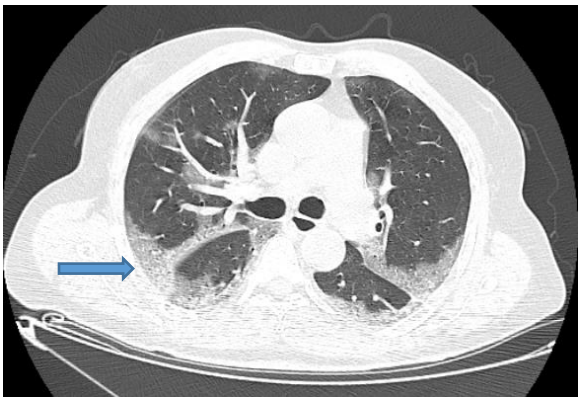
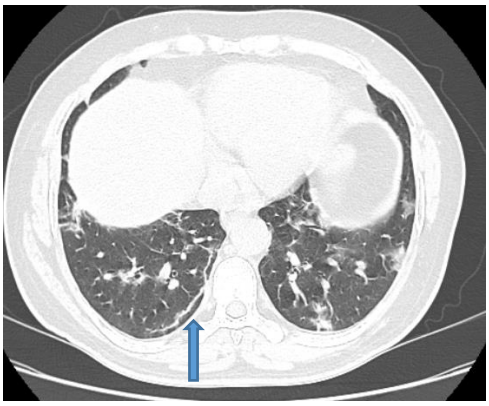
A)  B) 

**Figure 2**: A) A 60 years old male patient with bilateral ground glass opacity (arrow) with peripheral and dorsal distribution B) A 51 years old male patient with positive COVID PCR test with a right basal lung peripheral curved fibrosis (arrow)

Among 157 patients with GGO, 85(54.1%) had peripheral and 68(43.3%) had a diffuse distribution. And from 152 patients with a feature of consolidation, 110(72.4%) had a predominantly peripheral, and 39(25.6%) had a diffuse pattern of distribution.

Acute pulmonary embolism was found in 8 patients. Among patients with underlying lung disease which were not attributed to COVID-19 infection, lung fibrosis is seen in 11 patients, emphysema in 7, and cystic lung disease in 6 patients.

The mean (SD) chest CT severity score was found to be 13.6±6.2 and the median of 14. From the total number of patients, 95(49.2%) patients had a score of >18.

***Table 5**: CT severity score grading (Francone et al, 2020)*

| CT severity | Frequency(Percent) |
|---|---|
| Mild(<7) | 59(30.6%) |
| Moderate(8-17) | 59(30.6%) |
| Sever (>18) | 95(49.2%) |

In this study, the association of variables was assessed using Pearson's correlation. The association of age, sex, comorbidity, symptom, and duration of symptoms was assessed with a CT severity score. The result of the analysis shows a positive correlation of CT severity score with age and DM with a P-value < 0.01. The bivariate logistic regression showed that diabetic patients have a 1.6 times higher risk of developing severe COVID pneumonia

***Table 6**: Correlation of age and DM with chest CT severity score*

| Variables | Mean | SD | 1 | 2 |
|---|---|---|---|---|
| 1. Age | 50 | 14.2 | | |
| 2. DM | | | .413 | |
| 3. CT severity score | 13.6 | 6.2 | .0001* | .003* |

* P<0.01(2-tailed) ; N= 193 ,SD: Standard deviation

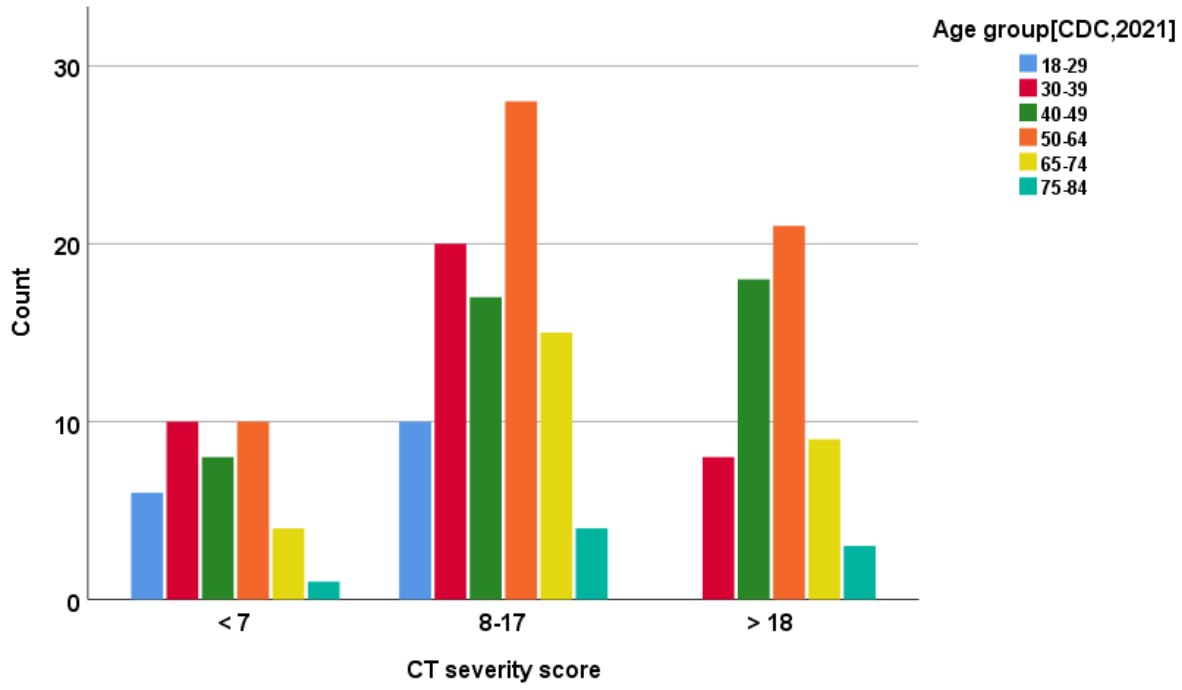



***Figure 3**: Correlation of Chest CT severity score with the age of patients*

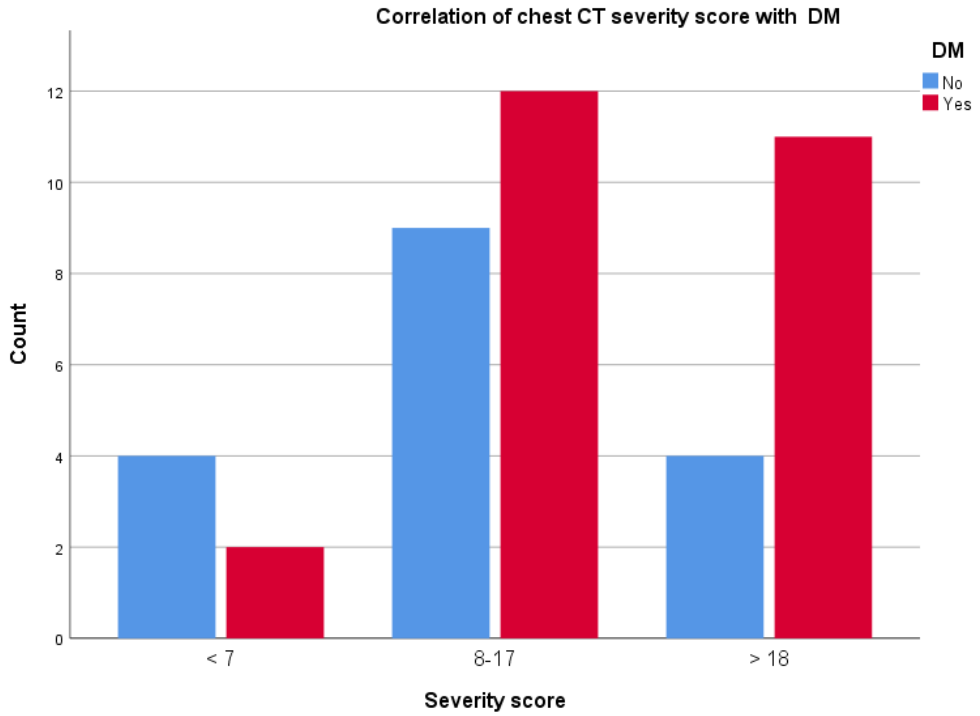



***Figure 4**: Correlation of chest CT severity score with patients with DM*

***Table 7:** Association of severe CT score with age of the patient and DM*

| | **Severe CT score(>18) Frequency(percentage)** | **COR 95% CI** | **AOR 95% CI** |
|---|---|---|---|
| 40-49 years | 18(41.9) | 2.16[0.39-11.9] | **1.6**[0.1-25.7] |
| 50-64 years | 20(33.9) | 1.54[0.28-8.3] | **2.8**[0.26-31.6] |
| 64-84 years | 9(32.1) | 1.42[0.23-8.5] | **2.5**[0.2-32.6] |
| DM | 11(78.6) | 2.01[0.56-7.31] | **1.6**[0.4-6.8] |

## Discussion

This study tried to show the demographic characteristics, clinical presentation, and imaging patterns among patients with suspected and confirmed COVID-19 pneumonia. The findings of the study reveal that there is a slight male predominant gender distribution with a male to female ratio of 1.5:1. The mean age of patients was 50±14.2 years and nearly half (47.7%) of the patients were above the age of 51 years. There is no documented gender predilection seen in many works of literature but the predominant old age distribution is similar to a study done in Tehran Iran [13] where the highest incidence of the disease occurred between the ages of 50-59 years, and in another study done in China [16] the median age was 47 years and 47% of the patients were above the age of 51 years.

In our study, among participants with known medical comorbidity, 62% had hypertension and 59.5% had DM representing the commonest underlying diseases in COVID-19 patients. This is comparable to a study done on 2012 patients in Pakistan [15], where the study identified uncontrolled diabetes with hypertension (n = 56; 26.4%) and controlled diabetes (n = 22; 10.37%) as common underlying medical illnesses among patients with COVID-19 pneumonia.

Cough and SOB were the most common complaints reported among the participants of this study accounting for 76% and 60.7% respectively. Fever as a presenting symptom was seen in only 18.75% of patients in this study. This pattern of presentation is comparable to findings in a study done in China [16] on 1099 patients which showed cough (67.8%) and fever (43.8%) were the most common symptoms. On the contrary, an Italian study [17] showed that fever was the predominant symptom observed in 97 (61%) of patients followed by cough and dyspnea presenting in 88 (56%) and 52 (33%). Since the majority of the participants in our study who underwent chest CT scans had been admitted to the COVID-19 treatment centers, there might be a modification of patient presenting symptoms by a treatment that might include antipyretic medications.

RT-PCR has been put as a gold standard reference to assess the diagnostic sensitivity of imaging modalities including chest CT scans. In our study, by selecting patients with CO-RAD scores of 4 and 5 as CT suggestive criteria for the diagnosis of COVID pneumonia, the overall CT positivity was 93.8%. Using the CT positivity rate and RT-PCR result of the patients, the sensitivity of chest

CT was shown to be 82.9% with a specificity of 16.7% in diagnosing COVID-19 pneumonia. As compared to the studies done in China and Italy, the sensitivity and specificity of chest CT are found to be lower. The study done in China[18] showed a sensitivity and specificity of chest CT in indicating COVID-19 infection to be 97% and 25 % respectively whereas, in the study done in Italy [19] on 773 patients, the chest CT sensitivity and specificity were determined to be 90.7% and 78.8% respectively. A large meta-analysis study done on 1431 patients, also showed the pooled sensitivity and specificity to be 94.6% and 46.5% respectively. Although , the studies have methodological quality issues, which may have led to an overestimation of sensitivity[21]

The lower sensitivity of chest CT in our study could be attributed to the selection bias since the majority of the patients have a positive PCR result upon admission to the treatment centers and the majority of patient imaged in the diagnostic centers were admitted patients with a confirmed diagnosis to look for complication. The slightly lower specificity registered in our study is also attributed to the small number of cases with RT-PCR negative results who underwent chest CT imaging.

Our study revealed that the predominant chest CT finding of predominant GGO and consolidation was seen in 83% and 80.4% of patients respectively followed by broncho-vascular thickening (35.4%) which is comparable to findings from multiple types of research done in China [15, 21, 22, 23] and Italy [16] showing that the predominant chest CT features among patients with COVID-19 pneumonia were multifocal ground-glass opacity and consolidation followed by broncho-vascular thickening.

Our study tried to see the variation of imaging appearance of symptomatic patient with a duration of symptoms. Patient who presented symptoms of < 4 days had a predominant consolidation (94.7%) and GGO (78.9%). Those patients with whose presentation between 5-8 days consolidation (86.3%) and GGO (77%) is still a predominant CT feature with bronchovascular thickening and curved peripheral fibrosis seen in 31.8% and 34% respectively. Among patient with symptom between 9-14 days and those with symptoms for more than 14 days although consolidation and GGO predominates the typical CT feature there is a higher percentage of bronchovascular thickening and curved peripheral fibrosis. The predominant consolidation and GGO and later development of bronchovascular thickening has also been described by Jin et al[26]

The bilateral, peripheral distribution with multi-lobar involvement seen in our study is also comparable to findings in multiple publications including literature published by Salehi S et al, which reviewed different publications and case reports on a total of 919 patients.

Using a semi-quantitative CT severity scoring system, Francone et al, 2020, it is found that lung pathologies predominantly involved the basal lungs, right lower lobe 186(96.4%), and left lower lobe 183(94.8%). The mean total CT severity score in our study was found to be 13.6±6.2. Using the same scoring system, Francone et al, found out that pathological involvement was mostly in the inferior lobes, right lower lobe (RLL) in 122 patients (93.8%), and left lower lobe (LLL) in 123 patients (94.6%). The mean (SD) CT severity score in that study was 12.3 ± 11.1.

In our study, the 25 point CT severity score is significantly correlated with the patient's age and comorbidity of diabetes suggesting that ÇOVID-19 pneumonia is severe in patients who are old age and having DM.

## Limitation of the study

Most of the patients included in the study were admitted to treatment centers and CT was taken for the assessment of complications like pulmonary embolism and post COVID fibrosis. For this reason, the majority of our patients are symptomatic, and since the majority of the patients were admitted with a positive PCR test and were admitted with moderate to severe illness it will create a sampling bias on the assessment of both CT sensitivity and severity score.

In addition in our study, the presenting symptoms of 107(55.4%) patients and underlying comorbidities of 144(74.6%) patients were not documented which makes it difficult to generalize the common presenting symptoms and comorbidities.

## Conclusion and recommendation

Most of the patients who were sent for chest CT evaluation from different treatment centers have positive CT findings which were suggestive of COVID pneumonia with a predominant GGO, consolidation, and broncho-vascular thickening. The pathologies showed to have a predominant dorsal and basal distribution. These imaging features are considered to be typical for COVID-19 pneumonia and are important to differentiate from other causes of pneumonia and ARDS.

From those patients with known clinical information, most of the patients have diabetes and hypertension and the main complaints of a symptomatic patient were cough, SOB, and chest pain.

The average CT severity score assessment was moderate (13.6) and there was a significant correlation between old age and DM with chest CT severity score, which signifies these factors directly influence the clinical outcomes of the patient.

The study primary involved hospital admitted patients and did not include patients who were asymptomatic or had mild symptoms to identify the CT imaging pattern, distribution, and severity score. We recommend future researches include a large number of patients with full clinical presentation and with an additional assessment of clinical outcome in comparison with the imaging assessment.

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# Appendix

**Questionnaire form**

1. **Demographic data**
   i. Age ☐< 18 years ☐ 19-35 years ☐ 36-50 years ☐> 50 years(13)
   ii. Sex ☐ Male ☐ Female
2. **Known comorbidity**

   ☐ Yes ☐ No

   **If yes**

   ☐ Hypertension ☐ underlying lung disease

   ☐ DM ☐ HIV/AIDS

   ☐ Cardiac illness ☐ Malignancy

   ☐ Renal disease ☐ others _____
3. **Clinical presentation**

   ☐ Asymptomatic ☐ Symptomatic

   If symptomatic

   ☐ Cough ☐ Headache

   ☐ SOB ☐ Arthralgia/Myalgia

   ☐ Fever ☐ loss of taste or smell

   ☐ Fatigue ☐ chest pain

   ☐ Sore throat ☐ others _____
4. **Duration of symptoms**

   ☐< 4 days ☐ 5-8 days ☐ 9-14 days ☐>14 days
5. **Covid-19 RT-PCR test result**

   ☐ Positive ☐ Negative ☐ Unknown
6. **CT protocol**

   ☐ Chest CT without contrast

   ☐Abdominopelvic CT without Contrast

   ☐ Chest and Abdominopelvic CT

☐ Chest CT with contrast

☐ CT angiography

☐Abdominopelvic CT with contrast

7. **Chest CT finding** ☐ Normal ☐ positive CT finding

   If there is finding

   i. Symmetry of involvement ☐ Unilateral ☐ Bilateral

   ii. Zonal Distribution of involvement ☐ central ☐ peripheral ☐ Diffuse

   iii. Predominant Lobar distribution ☐ RUL ☐ RML ☐ RLL ☐ LUL ☐ LLL

   iv. Predominant AP distribution ☐ Ventral ☐ Dorsal ☐ None

8. **Chest CT features**

   **i. Typical feature**

   ☐ GGO ☐Bronchovascular thickening ☐ Fibrosis (curved, subplueral)

   ☐ Crazy paving ☐ Traction bronchiectasis

   ☐ Consolidation ☐ Halo sign

   **ii. Atypical features**

   ☐Mediastinal lymphadenopathy ☐ Nodular opacity

   ☐ Pleural effusion ☐ Pneumothorax

   ☐ Tree in bud opacity ☐ Cavitation

9. **GGO**

   ☐ Peripheral ☐ Peripheral and central

   ☐ Central ☐ None

10. **Consolidation**

    ☐ Peripheral ☐ Peripheral and central

☐ Central ☐ None

**11. Multiple round consolidation**

☐Yes ☐ No

**12. Margin of consolidation**

☐ Sharp ☐not applicable ☐ Hazy

**13. Right Upper lobe**

a. 0% (0 Points)

b. <5% (1 Point)

c. 5 - 25% (2 Points)

d. 25 - 50% (3 Points)

e. 50 - 75% (4 Points)

f. 75-100% (5 Points)

**14. Right Middle lobe**

a. 0% (0 Points)

b. <5% (1 Point)

c. 5 - 25% (2 Points)

d. 25 - 50% (3 Points)

e. 50 - 75% (4 Points)

f. 75-100% (5 Points)

**15. Right Lower lobe**

a. ○ 0% (0 Points)

b. ◉ <5% (1 Point)

c. ○ 5 - 25% (2 Points)

d. ○ 25 - 50% (3 Points)

e. ○ 50 - 75% (4 Points)

f. ○ 75-100% (5 Points)

**16. Left upper lobe**

a. ○ 0% (0 Points)

b. ○ <5% (1 Point)

c. ○ 5 - 25% (2 Points)

d. ○ 25 - 50% (3 Points)

e. ○ 50 - 75% (4 Points)

f. ○ 75-100% (5 Points)

**17. Left lower lobe**

a. ○ 0% (0 Points)

b. ○ <5% (1 Point)

c. ○ 5 - 25% (2 Points)

d. ○ 25 - 50% (3 Points)

e. ○ 50 - 75% (4 Points)

f. ○ 75-100% (5 Points)

**18. Underlying lung pathology( unrelated to current presentation with incidental finding)**

☐ Lung fibrotic changes ☐ Cystic changes

☐ Lung parenchymal volume loss ☐ Emphysema

☐ Lung mass (primary or metastatic) ☐ others

**Research consent forms**

**Participant's information sheet**

**Participant ID: _____**

**For adult participants (above the age of 18 years)**

**AAU-CHS, Department of radiology**

**Research topic**: Crossectional study on the diagnostic sensitivity and imaging patterns of chest CT among patients with suspected and confirmed COVID 19 infection in Addis Ababa, Ethiopia

**Purpose of the study**: The research with the above title is intended to assess the role of chest CT scan in the diagnosis and evaluation of imaging features and severity of chest infection due to COVID-19 pneumonia. During the study process, the investigator will collect the patient's clinical information including age, sex, clinical presentation, any co-morbidity, and COVID-19 RT-PCR result of the patient along with the imaging information of the patient as obtained from the CT scan.

**Right of participants**: Starting from the data collected through the process of analysis and publication of the study, the investigator assures that all the patients' information will be kept confidential under all circumstances and the participants have the right to defer to involve and to withdraw from the research at any time without having to give a reason and without any consequences.

**Benefit and risk**: There is no individual benefit obtain from the participation and there is no additional risk imposed on the participants.

**Consent form**

I confirm that I have read and understood the information provided above and I also understand that my participation is voluntary.

I agree to take part in the above-mentioned study

| _____ | _____ | _____ |
| --- | --- | --- |
| Name of participant | Signature | Date |

**Research consent form**

**Participant's information sheet**

**Participant ID: _____**

**For parents/guardians (for those who are 12 to 18)**

**AAU-CHS, Department of radiology**

**Research topic**: Crossectional study on the diagnostic sensitivity and imaging patterns of chest CT among patients with suspected and confirmed COVID 19 infection in Addis Ababa, Ethiopia

**Purpose of the study**: The research with the above title is intended to assess the role of chest CT scan in the diagnosis and evaluation of imaging features and severity of chest infection due to COVID-19 pneumonia. During the study process, the investigator will collect the patient's clinical information including the age, sex, clinical presentation, any co-morbidity, and COVID-19 RT-PCR result of the patient along with the imaging information of the patient as obtained from the CT scan.

**Right of participants**: Starting from the data collected through the process of analysis and publication of the study, the investigator assures that the patients all information will be kept confidential at all circumstances and the parent/guardian has the right to defer from their child to involve and to withdraw from the research at any time without having to give a reason and without any consequences.

**Benefit and risk**: There is no individual benefit obtain from the participation and there is no additional risk imposed on the participants.

**Consent form**

I confirm that I am the parent/legal guardian of the child and I have read and understood the information provided above and I also understand that the participation is voluntary.

I confirm for the child to take part in the above-mentioned study

| _____ | _____ | _____ |
|---|---|---|
| Name of parent/guardian | Signature | Date |

**Research assent form**

**Participant ID: _____**

**For those who are 12 to 18**

**What is a research study?**

Research studies help us learn new things. We can test new ideas. First, we ask a question. Then we try to find the answer.

This paper talks about our research and the choice that you have to take part in it. If you have any questions you can ask us any time.

**Why are we doing this research?**

We are doing this research to find out more about the general role of Chest CT scan imaging in the new COVID-19 pneumonia diagnosis. During the research process, the data collector will take your personal information such as your age, sex, any comorbidities, COVID-19 test result, and your chest CT scan results to include them in the research.

**Important things to know…**

You get to decide whether or not you want to take part in this research. This research will not directly help you. We do hope to learn something from this research and someday we hope it will help other children who have the same illness as you. If you don't want to be in the study, you don't have to be. There will not be any punishment if you do not want to participate in the research. It is also OK to say yes and change your mind later.

If you want to be in the research after we talk, please write your name below. We will write our name too. This shows we talked about the research and that you want to take part.

**Name of Participant** _____

(To be written by child/adolescent)

**Name of Researcher** _____

**Signature of Researcher** _____

_____ _____

**Date** **Time**

**የጥናት ተሳታፊነት መፍቀጃ ቅፅ**

**የተሳታፊ ቁጥር፡** ———————————

**ለአዋቂ ተሳታፊዎች (18 አመትና ከዚያ በላይ እድሜ ላላቸው ተሳታፊዎች)**

**የጥናቱ ርዕስ፡-**

**የጥናቱ አስፈላጊነት፡-** ከላይ በተጠቀሰው ርዕስ የሚሰራው ጥናት የሳንባ ሲቲ ስካን በኮቪድ-19 ታካሚዎች የምርመራ ሂደት ላይ የሚያደርገውን አስተዋፅዎ ለማወቅ የሚደረግ ሲሆን ተመራማሪው የታካሚዎችን የግል መረጃ እንደ እድሜ፣ ፆታ፣ ተ[1]ዳኝ ህመሞች፣ የኮቪድ-19 ምርመራ ውጤትና የሳንባ ሲቲ ስካን ውጤት ይሰበስባል።

**የተሳታፊዎች መብት፡-** ለጥናቱ በሚደረግ የመረጃ ስብሰባ፣ ማጠናቀርና ህትመት ወቅት ተመራማሪው የተሳታፊዎቹን ማንነትና የግል መረጃና በምስጢር ይጠብቃል። ተሳታፊዎች በማንኛውም ጊዜ ተጨማሪ ምክንያት ወይም ገለፃ ማቅረብ ሳይጠበቅባቸው ራሳቸውን ከጥናቱ ማግለል ይችላሉ።

**ጥቅምና ጉዳት፡-** በዚህ ጥናት ለሚሳተፉ ተሳታፊዎች የሚሰጥ የገንዘብም ሆነ የቁሳቁስ ጥቅም የለም። ተሳታፊዎች በዚህ ጥናት ላይ በመሳተፋቸው የሚደርስባቸው ጉዳት የለም።

ከላይ የተጠቀሰውን መረጃ አንብቤና ተረድቼ ካለማንም አስገዳጅነት በጥናቱ ላይ ለመሳተፍ ፈቅጃለሁ።

| የተሳታፊው ስም | ፊርማ | ቀን |
|---|---|---|
| _____ | _____ | _____ |

**የጥናት ተሳታፊነት መፍቀጃ ቅፅ**

**የተሳታፊ ቁጥር፡** _____

**ለታዳጊና ህፃናት ተሳታፊዎች በወላጆች የሚሞላ ቅፅ (ከ12 እስከ 18 አመት እድሜ ላላቸው ተሳታፊዎች)**

**የጥናቱ ርዕስ፡-**

**የጥናቱ አስፈላጊነት፡-** ከላይ በተጠቀሰው ርዕስ የሚሰራው ጥናት የሳንባ ሲቲ ስካን በኮቪድ-19 ታካሚዎች የምርመራ ሂደት ላይ የሚያደርገውን አስተዋፅዎ ለማወቅ የሚደረግ ሲሆን ተመራማሪው የታካሚዎችን የግል መረጃ እንደ እድሜ፣ ፆታ፣ ተ[1]ዳኝ ህመሞች፣ የኮቪድ-19 ምርመራ ውጤትና የሳንባ ሲቲ ስካን ውጤት ይሰበስባል።

**የተሳታፊዎች መብት፡-** ለጥናቱ በሚደረግ የመረጃ ስብሰባ፣ ማጠናቀርና ህትመት ወቅት ተመራማሪው የተሳታፊዎቹን ማንነትና የግል መረጃና በምስጢር ይጠብቃል። ተሳታፊዎች በማንኛውም ጊዜ ተጨማሪ ምክንያት ወይም ገለፃ ማቅረብ ሳይጠበቅባቸው ራሳቸውን ከጥናቱ ማግለል ይችላሉ።

**ጥቅምና ጉዳት፡-** በዚህ ጥናት ለሚሳተፉ ተሳታፊዎች የሚሰጥ የገንዘብም ሆነ የቁሳቁስ ጥቅም የለም። ተሳታፊዎች በዚህ ጥናት ላይ በመሳተፋቸው የሚደርስባቸው ጉዳት የለም።

ከላይ የተጠቀሰውን መረጃ አንብቤና ተረድቼ ካለማንም አስገዳጅነት ልጄ በጥናቱ ላይ እንዲሳተፍ ፈቅጃለሁ።

| የወላጅ / የአሳዳጊ ስም | ፊርማ | ቀን |
| --- | --- | --- |
| _____ | _____ | _____ |

**የጥናት ተሳታፊነት መፍቀጃ ቅፅ**

**የተሳታፊ ቁጥር፡** _____

**ለታዳጊና ህፃናት ተሳታፊዎች (ከ12 እስከ 18 አመት እድሜ ላላቸው ተሳታፊዎች)**

**ምርምር/ጥናት ምንድን ነው?**

ምርምር/ጥናት በአካባቢያችን ስላሉ አዳዲስ ክስተቶች ለመማር ይረዳናል። ከዚህ በተጨማሪም አዳዲስ ሃሳቦችን ለመፈተን ይጠቅመናል። በመጀመሪያ ጥያቄዎችን እንጠይቃለን በመቀጠልም መልሶቹን ለማግኘት እንሞክራለን።

ይህ ቅፅ እየሰራነው ስላለው ጥናት ከመግለፁም በተጨማሪም አንተ/አንቺ በጥናቱ ተሳታፊ ለመሆን ፍቃድ የምትሰጥበት/ጪበት ነው። ጥናቱን በተመለከተ መጠየቅ የምትፈልገው/ጊው ማንኛውንም አይነት ጥያቄ ካለ በማንኛውም ሰዓት መጠየቅ ይቻላል።

**የጥናቱ አስፈላጊነት**

ይህ ጥናት እ.ኤ.አ. በ2019 በተከሰተው የኮቪድ-19 ወረርሽኝ የታካሚዎች የምርመራ ሂደት ላይ የሳንባ ሲቲ ስካን ምርመራ የሚያደርገውን አስተዋፅዎ ለማወቅ የሚደረግ ጥናት ሲሆን ተመራማሪው የአንተን/ቺን የግል መረጃ እንደ እድሜ፣ ፆታ፣ ተ[1]ዳኝ ህመሞች፣ የኮቪድ-19 ምርመራ ውጤትና የሳንባ ሲቲ ስካን ውጤት ይሰበስባል።

**የጥናቱ ጥቅምና ጉዳት**

የጥናቱ ተሳታፊ ለመሆን ፍቃድ የምትሰጠው/ጪው አንተ/ቺ ነህ/ሽ። በዚህ ጥናት በመሳተፍህ/ሽ በቀጥታ የምታገኘው/ኚው የገንዘብ ወይም የቁሳቁስ ጥቅም የለም። ነገር ግን ከዚህ ጥናት የሚገኘው መረጃ ከአንተ/ቺ ጋር ተመሳሳይ ህመም ያላቸውን ታዳጊዎችና ህፃናት ለመርዳት ይጠቅማል። በጥናቱ ተሳታፊ ለመሆን ካፈለግክ/ሽ የሚደርስብህ/ሽ ምንም ጉዳት ወይም ቅጣት የለም። የጥናቱ ተሳታፊ ለመሆን ፍቃድ ከሰጠህ/ሽ በ|ላ ከጥናቱ ለመውጣት ከወሰንክ/ሽ በማንኛውም ሰዓት መውጣት ትችላለህ/ትችያለሽ።

ከላይ የተጠቀሰውን መረጃ አንብበህ/ሽና ተረድተህ/ሽ በጥናቱ ተሳታፊ ለመሆን ከተስማማህ/ሽ ከዚህ በታች የአንተን/ቺን ስም እና የእኛን ስምና ፊርማ እናስቀምጣለን።

| የተሳታፊው ስም | ፊርማ | ቀን |
|---|---|---|
| _____ | _____ | _____ |
| የተመራማሪው ስም | ፊርማ | ቀን |
| _____ | _____ | _____ |