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# Radiological Evaluation of Imaging of CT-Thorax Among Comorbid and Vaccinated.

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**KEYWORDS**

COVID-19, Vaccination, Pandemic, Computed Tomography Severity Score (CTSS), Immunization.

**ABSTRACT**:

During the backdrop of human history, Coronavirus Disease 2019 (COVID-19) emerges as the most cataclysmic viral scourge in a century. The esteemed World Health Organization (WHO) bestowed the mantle of 'pandemic' upon it on the fateful day of March 11, 2020. This viral malaise primarily disseminates via respiratory exudates, rendering the practice of maintaining social distance the foremost fortification. Since the genesis of this pandemic, an array of variant strains has arisen, with the Delta variant emerging as the harbinger of the second tumultuous wave of COVID-19 in India. Mass immunization emerges as the quintessential prophylactic measure, constituting the vanguard against viral propagation and the architect of herd immunity. It is prudent to acknowledge that vaccination does not confer invincibility against infection; rather, it mitigates the gravity of the ailment. The vaccine emerges as an oasis in the midst of pandemic pandemonium. Our investigation accentuates that individuals who have undergone vaccination, particularly those who have received both doses, manifest clinically inconspicuous symptoms and exhibit a subdued Computed Tomography Severity Score (CTSS), facilitating a rapid convalescence. In stark contrast, the unvaccinated populace presents with symptoms of moderate to severe intensity, and their CTSS frequently surmounts the threshold of eight, necessitating hospitalization and harbouring a bleak prognosis. Consequently, vaccination emerges as a salient strategy to alleviate the burden placed upon the already beleaguered healthcare infrastructure. The occasion of immunization also serves as a propitious juncture to disseminate messages that incentivize prudent behaviour, diminish the risk of COVID-19 transmission, elucidate the identification of symptomatic manifestations, and furnish guidance pertaining to appropriate action.

**Introduction:**

In the annals of medical history, Coronavirus Disease 2019 (COVID-19) has arisen as a cataclysmic viral affliction, casting a pall over the globe for the past century. The genesis of this malaise traces back to December 2019, emanating from the city of Wuhan in China.[1] The World Health Organization (WHO), recognizing the escalating threat, declared COVID-19 a Public Health Emergency of International Concern on January 30, 2020, and subsequently elevated it to the grim status of a pandemic on March 11, 2020. In the Indian subcontinent, the first confirmed case of COVID-19 was recorded on January 30, 2020, marking the inception of an enduring battle.[2] This viral adversary primarily disseminates through the respiratory route, as individuals unwittingly inhale droplets and minuscule particles exhaled by the infected populace during their daily rituals of breathing, speaking, coughing, sneezing, or even singing.[3] The propensity for transmission surges when people engage in close physical proximity, underscoring the pivotal role of social distancing as a cardinal preventive measure to curb the pernicious spread of the virus. While high-grade fever, dry cough, and fatigue initially took the center stage as typical prodromal symptoms, the past year has unveiled a plethora of atypical presentations, including aches, sore

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throat, diarrhea, conjunctivitis, headache, loss of taste or smell, and abdominal discomfort. Those bearing the added burden of comorbidities such as diabetes mellitus, hypertension, heart disease, and chronic obstructive pulmonary disease (COPD) face an augmented risk of severe affliction. Diagnostic endeavours invariably lead symptomatic patients to the threshold of computed tomography (CT) scans, facilitating a comprehensive assessment of lung involvement in terms of patterns and severity. High-resolution CT (HRCT) scans consistently reveal the hallmark features of ground-glass opacities (GGO) and the subsequent consolidation of lung tissue. The dynamic nature of this pathogenic entity is underscored by its rapid mutational propensity, giving rise to an array of variant strains. The recent Delta variant, for instance, has been a harbinger of the resurgence in cases, marking the second wave of COVID-19 in India. Mass vaccination emerges as the most efficacious preventive strategy, functioning as a formidable barrier against transmission and fostering the elusive herd immunity. In the Indian context, the primary vaccine contenders are Covishield and Covaxin, both government-authorized and demonstrating comparable efficacy. Recently, the Sputnik V vaccine has also joined the ranks of authorized vaccinations. It is imperative to recognize that vaccination, while a powerful tool, does not bestow absolute immunity against infection. Nonetheless, it serves as a vital shield, diminishing the gravity of the affliction. As of June 2021, India's vaccination efforts place it 16th among the 30 most populous countries, with 18.9% of its population having received vaccines. According to data released in mid-January by the Ministry of Health and Family Welfare, India has administered a staggering 1.56 billion vaccine doses, accounting for 64% of the total vaccinated population. In light of this, the pressing need of the hour is to accelerate the vaccination rate, fortifying the nation's defenses against the relentless viral adversary.[4]

Variability in Symptom Presentation: The symptoms of COVID-19 are far from uniform. While fever, cough, and fatigue are common, individuals may experience a wide range of other symptoms, including but not limited to shortness of breath, chest pain, confusion, skin rashes, and gastrointestinal disturbances. The diverse clinical presentations of the virus challenge healthcare providers to maintain a high index of suspicion.[5]

Long COVID: A growing concern is the phenomenon of "Long COVID" or post-acute sequelae of SARS-CoV-2 infection (PASC). Some individuals, even those with initially mild symptoms, continue to experience lingering effects, such as persistent fatigue, cognitive impairments, and respiratory issues for an extended period after their acute illness.[6]

Impact on Mental Health: The psychological toll of the pandemic is profound. Isolation, grief, economic hardship, and uncertainty have led to a surge in mental health conditions. Addressing the mental health crisis arising from the pandemic is as crucial as managing the physical aspects of the disease.[7]

Vaccine Hesitancy: Despite the availability of vaccines, vaccine hesitancy remains a significant challenge. Public health campaigns and education are necessary to address misinformation and encourage broader vaccine acceptance.[8]

Vaccine Equity: Access to vaccines is not equitable worldwide. Disparities in vaccine distribution and availability persist, underscoring the importance of international collaboration to ensure that vaccines reach all corners of the globe.[9]

Booster Shots: The emergence of new variants and waning immunity have led to discussions about the necessity of booster shots. These additional doses aim to enhance and prolong the protection conferred by the initial vaccination.

Public Health Measures: While vaccination is a pivotal strategy, the maintenance of public health measures, such as mask-wearing, good hand hygiene, and well-ventilated spaces, remains vital in reducing transmission, especially in areas with low vaccine coverage or high infection rates.

Preparedness for Future Pandemics: The COVID-19 pandemic has highlighted the need for improved global pandemic preparedness and early warning systems to mitigate the impact of future outbreaks.[10]

Research and Data Sharing: Ongoing research and the sharing of data and insights are crucial for a better understanding of the virus, its variants, and the effectiveness of vaccines and treatments. Collaborative efforts among scientists and institutions worldwide are essential.

Healthcare Infrastructure: The pandemic has exposed weaknesses in healthcare infrastructure in various regions. Investments in healthcare systems are necessary

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to enhance capacity and resilience against future health crises.[11]

Antiviral Medications: The development and availability of effective antiviral medications for COVID-19 can provide an additional layer of defense, especially for those who cannot be vaccinated.

Global Solidarity: The fight against COVID-19 is a global endeavor. Cooperation among nations, sharing resources, and supporting countries with limited healthcare infrastructure are essential to control the pandemic's global impact.[12]

In this evolving landscape, the world continues to grapple with the multifaceted challenges posed by COVID-19, demanding a comprehensive and sustained response from the global community.

**Material and Method**

The research study was conducted at the Department of Radiology, PIMS, Islampur, Sangali. It adopted a cross-sectional observational study design. Given the absence of established prevalence and incidence data for the disease under scrutiny, all patients underwent chest High-Resolution Computed Tomography (HRCT) imaging as a diagnostic tool for confirming COVID-19 swab positivity during the defined study period. This cohort encompassed a total of 325 patients, comprising 74 who had received vaccinations and 250 who had not. The sampling technique employed for patient selection was random. Prior to their participation in the study, all patients provided written informed consent, a fundamental ethical requirement. Furthermore, the study received formal approval from the institutional ethical committee before initiation. The data collection phase spanned from May 14 to June 13. The equipment utilized for HRCT imaging was used, ensuring high-quality imaging for precise evaluation. Data collection was facilitated using pretested, predesigned, and semi structured proforma, which served as the foundation for systematically gathering essential information. Patients who had tested positive for COVID-19 through Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR), regardless of their vaccination status, were included in the study, recognizing their relevance to the research objectives. Conversely, patients who tested negative through RT-PCR were excluded from the study, aligning with the research's focus on the positive cases for an in-depth radiological evaluation.[13]

**Data Collection**

In this retrospective study, we meticulously gathered clinical and chest imaging data. This comprehensive dataset encompassed various crucial aspects, including epidemiological information, the vaccination status of patients, their underlying comorbidities, and detailed characteristics of chest Computed Tomography (CT) scans. The CT chest data included insights into the patterns of lung involvement and the calculation of CT Severity Score (CTSS).

Upon the culmination of the data collection process, the clinical data pertaining to laboratory-confirmed COVID-19 patients were meticulously compiled and systematically organized into tabular formats, facilitating subsequent analysis. It's imperative to note that the diagnosis of COVID-19 was established by the presence of positive Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR) samples obtained from nasal and throat swab specimens. This diagnostic criterion adhered to the guidelines set forth by the World Health Organization (WHO) in their interim guidance.

The epidemiological data, which encompassed age and gender information, were rigorously documented. Simultaneously, clinical data, which included an assessment of comorbidities, was thoroughly collected. The core of this study's dataset consisted of the 670 patients who all underwent chest CT scans. These scans provided valuable insights into the patterns of lung involvement and the calculation of CTSS, further enriching the dataset and contributing to the comprehensive analysis of the study.

**Review of CT Images**

In our study, we conducted a meticulous analysis of Computed Tomography (CT) images obtained with high precision, utilizing thin sections of 0.625mm, employing a CT machine. These CT images underwent a comprehensive assessment to discern specific features indicative of COVID-19 infection, namely the presence of ground-glass haziness and consolidation.

The CT findings were systematically categorized into four primary classifications: typical, indeterminate, atypical, or negative for COVID-19 pneumonia based on characteristic radiological features. Typical features encompassed those widely reported in the literature as frequently observed in COVID-19 pneumonia cases. These features included bilateral, peripheral Ground-

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Glass Opacities (GGOs) with or without consolidation, as well as the occurrence of "crazy paving." Indeterminate features referred to multifocal, diffuse, central, or unilateral GGOs. Atypical features, on the other hand, encompassed findings that were considered uncommon or not typically associated with COVID-19 pneumonia, such as the presence of consolidation without GGOs, cavitation, or pleural effusion. Cases were categorized as "negative for pneumonia" when no discernible lung parenchymal abnormalities attributable to infection were evident.

To quantitatively assess the severity of lung involvement, we calculated a severity score. This score was based on a meticulous evaluation of the percentage of involvement in each lobe. Each lobe's involvement was individually scrutinized, and a score ranging from 1 to 5 was assigned, with the following representations:

1: Signifying less than 5% involvement of the lobe.
3: Indicating lobar involvement within the range of 26% to 50%.
2: Denoting lobar involvement between 5% and 25%.
5: Designating lobar involvement exceeding 75%.
4: Representing lobar involvement spanning from 51% to 75%.

The final composite score was determined by summing the individual lobar scores, resulting in a cumulative score out of a total of 25.

The assessment of the acquired High-Resolution CT (HRCT) images was conducted by two radiologists who were deliberately kept blind to the vaccination status of the patients. To ensure the reliability of the findings, the interobserver agreement was assessed, and a high level of agreement was determined with a Cronbach's alpha value of 0.997 (95% confidence interval [CI]: 0.995–0.998). This signifies a strong consensus between the radiologists in their interpretations of the CT images, ensuring the robustness of our analysis.

**Statistical Analysis**

The data from our study were subjected to a rigorous analysis using Graph Pad Prism software, a well-established tool for data analysis and statistical evaluation. Throughout the analysis, tables and pie charts were thoughtfully employed to present the results in a clear and informative manner, enhancing the accessibility and comprehensibility of the findings.

These visual aids, in the form of tables and pie charts, played a pivotal role in conveying the essential information derived from the data analysis, ensuring that the results were both visually appealing and logically structured for the benefit of the readers and researchers. This approach enabled us to provide a comprehensive and well-organized presentation of the study's outcomes, making it easier for the audience to grasp and interpret the data effectively.

**Results & Discussion**

A retrospective comparative analysis was conducted on a cohort of RT-PCR COVID-19-positive patients. The primary objective was to assess their clinical data, vaccination status, and High-Resolution Computed Tomography (HRCT) findings, with a focus on determining the disease's severity in relation to the patient's vaccination status. Additionally, the study aimed to ascertain the prognostic utility of chest HRCT in patient management.

Out of the total of 325 patients included in our study, those with unknown vaccination status and a negative RT-PCR status were excluded from the analysis. The data collection period spanned from April 15 to May 10. Among the remaining patients, 76 had received vaccination, with 50 patients having received a single dose, and 26 having received two doses of the vaccine (as illustrated in Figure 1).

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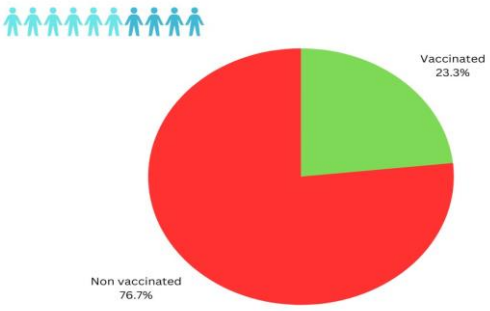


**Figure 1** A pie chart representing the proportion of patients who received vaccination versus those who did not.

The majority of patients in this study were in their fifth decade of life, with an average age of 55.4 years in the vaccinated group and 45.7 years in the nonvaccinated group. This age difference was found to be highly statistically significant between the two groups (see Table 1). Additionally, a predominant number of male patients were observed in both the vaccinated group (46% males and 34% females) and the nonvaccinated group (54% males and 66% females).

Out of the total 325 patients, 70% (228 patients) were symptomatic, with the most common symptoms reported across both groups being fever, cough, and malaise. The average duration of symptoms in the vaccinated group was 4-14 days respective. Among the vaccinated group, the most prevalent comorbidity was diabetes (47%), followed by hypertension (55%) and chronic lung conditions such as K-chest/COPD (10%). In the nonvaccinated group, hypertension was the most common comorbidity (30%), followed by diabetes (24%) and chronic lung conditions (7%). It is noteworthy that there was no significant difference observed in the prevalence of comorbidities between the two groups (as indicated in Table 2 and Figure 2).

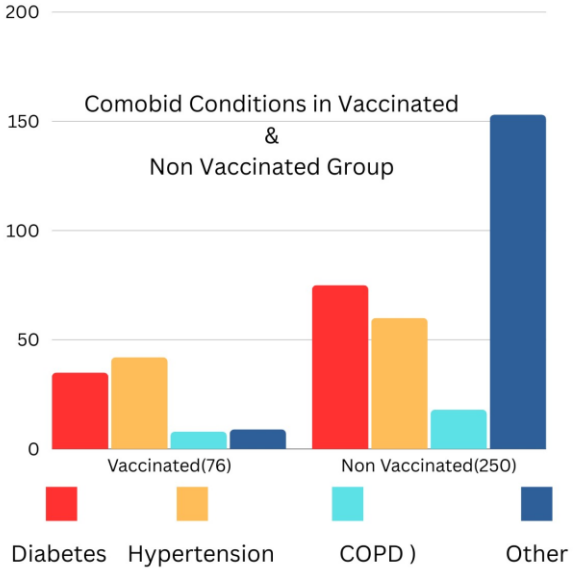


**Figure 2** "Here is a bar chart depicting the prevalence of comorbidities in both the vaccinated and nonvaccinated groups."

In the vaccinated group, out of the 76 patients, 44 (58%) exhibited typical High-Resolution Computed Tomography (HRCT) findings indicative of COVID-19 pneumonia. Additionally, 23 patients (30%) had indeterminate findings, 7 patients (9%) displayed atypical patterns, and 3 patients (3%) showed negative HRCT results.

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In contrast, among the 250 nonvaccinated patients, 150 (60%) had typical HRCT findings, 45 patients (18%) had indeterminate patterns, 33 patients (13.2%) exhibited atypical features, and 22 patients (8.8%) received negative HRCT results. Notably, a statistically significant difference was observed between the two groups, as highlighted in Figure 3.

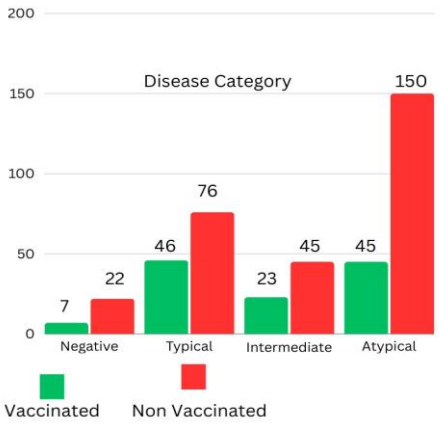


**Figure 3** "Bar graph illustrating the breakdown of disease categories within the vaccinated and nonvaccinated groups."

The typical findings of COVID-19 on chest High-Resolution Computed Tomography (HRCT) were stratified based on the CT Severity Score (CTSS) into three categories: mild (<8), moderate (9–15), and severe (>15).

In the nonvaccinated group, there were 76 patients with typical COVID-19 findings, while in the vaccinated group, 46 patients exhibited these typical features. Among the nonvaccinated group, 60 patients (24%) had a mild CTSS, whereas 85 patients (33.8%) in the vaccinated group fell into this category. This discrepancy was found to be statistically significant.

In Addition to this in the nonvaccinated group,124 patients, 30 patients (23.1%) displayed moderate symptoms.

Furthermore, in the nonvaccinated group, 88 patients (35%) presented with severe CTSS, while in the vaccinated group, 18 patients (23.1%) displayed severe CTSS. Once again, these differences were statistically significant, as depicted in Figure 4.

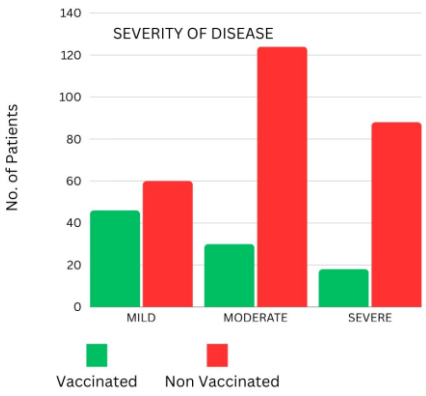


**Figure 4** Bar chart showing distribution of severity of disease among vaccinated and nonvaccinated groups.

**Discussion**:

Coronaviruses, an extensive family of viruses, engender an array of maladies, encompassing the common cold and more formidable conditions like Middle East respiratory syndrome (MERS-CoV) and severe acute respiratory syndrome (SARS-CoV). A novel entrant in

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this viral congregation is CoV/COVID-19, an uncharted strain hitherto unknown to humanity. The World Health Organization (WHO) recognized the gravity of the situation in March 2020, pronouncing the COVID-19 outbreak as a "pandemic." The inaugural wave of the COVID-19 pandemic unfurled its grip upon India in mid-March 2020, a relentless three-month ordeal. This surging health crisis thrust a formidable challenge upon the healthcare system, mandating the adoption of stringent measures like social distancing, home confinement, and austere lockdowns. To combat this pernicious scourge, the only viable recourse was to cultivate herd immunity through efficacious vaccination. India initiated its vaccination campaign on January 16, 2021, nearly a year since the first documented case. Alas, come early April 2021, a momentous second wave inundated the nation. By April 9, India's active cases surpassed one million, and by April 12, it overtook Brazil as the second most COVID-19 afflicted nation globally. Diverse factors have been cited as potential contributors to this resurgence, including the proliferation of highly contagious variants like lineage B.1.617, an insufficiency of preparation as temporary hospitals dismantled when cases abated, neglecting the construction of new facilities, and a lax implementation of health and safety protocols during weddings, festivals, sporting events, state and local elections, and in public spaces. Simultaneously, various virology laboratories conducted vaccine trials and assessed their efficacy. The vaccine produced by AstraZeneca-SKBio in the Republic of Korea and the Serum Institute of India received WHO's emergency use authorization. This vaccine underwent rigorous scrutiny by the European Medicines Agency (EMA) before receiving a recommendation for marketing authorization for individuals aged 18 and older. The Covishield vaccine, designed to combat COVID-19, exhibits an efficacy rate of 88% against symptomatic SARS-CoV-2 infection. A longer gap between doses, ranging from 8 to 12 weeks, has shown to enhance vaccine efficacy. SAGE currently advocates the usage of the AZD1222 vaccine in accordance with the WHO Prioritization Roadmap, irrespective of the presence of virus variants in a given country. As of now, no substantive data exists concerning the impact of AZD1222 on transmission or viral shedding. In the interim, it is imperative to uphold and reinforce effective public health measures, such as masking, social distancing, rigorous handwashing, respiratory and cough etiquette, avoiding congregations, and ensuring adequate ventilation. As of April 19, 2021, the AstraZeneca vaccine remains a reliable safeguard against the perils of COVID-19, including mortality, hospitalization, and severe illness. This vaccine is not recommended for those under the age of 18. The prescribed regimen consists of two intramuscular doses (0.5mL each), administered with a gap of 8 to 12 weeks. Additional research is warranted to fathom the potential for long-term protection following a solitary dose. Our comprehensive study encompassed 670 RT-PCR confirmed COVID-19 patients who sought treatment at SMS Hospital, Jaipur, owing to COVID-19-related symptoms. The study's ambit included an evaluation of demographic data, vaccination status, comorbidities, and chest HRCT findings among these patients. The study encompassed a broad age spectrum, with the exception of pediatric cases, the majority clustered in their fifth decade of life. underscoring the pivotal role of radiological diagnosis in guiding patient management and curtailing the transmission of the disease among susceptible individuals. Comorbidities, on the other hand, served as a catalyst, exacerbating both the severity and mortality of the disease. Among the vaccinated group, diabetes was the most prevalent comorbidity (observed in 52% of patients), while hypertension featured prominently (30%) in the nonvaccinated group. Patients with multiple comorbidities faced a grim prognosis, necessitating hospitalization, oxygen therapy, and steroid administration.

In India, the diagnosis of COVID-19 pneumonia predominantly relies on clinical assessment, validated by SARS-CoV-2 nucleic acid RT-PCR. However, the sensitivity of chest HRCT surpasses that of RT-PCR for COVID-19 diagnosis. Characteristic chest CT findings in COVID-19 manifest as bilateral ground-glass opacities (GGOs), primarily distributed in a peripheral and basal pattern. The Radiological Society of North America Expert Consensus established four categories for reporting CT imaging findings potentially indicative of COVID-19, each delineated by standardized terminology. The "typical" classification designates frequently reported features specific to COVID-19 pneumonia, while "indeterminate" indicates nonspecific imaging features in the absence of typical manifestations.

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