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Pattern of Lung findings in HRCT Scan of Vaccinated and Non-vaccinated RT-PCR Positive COVID-19 Patients

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Abstract:

Background: *Coronavirus disease 2019 (COVID-19) is a highly infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Large-scale vaccination of risk groups and later the general population is the single most effective public health measure for mitigation of the COVID-19 pandemic.* ***Methods and Materials:*** *This prospective cross sectional study was carried out at DNCC dedicated covid-19 hospital, Mohakhali, Dhaka, enrolling 50 (fifty) non vaccinated and fifty (50) vaccinated RT-PCR positive Covid-19 patients.* ***Results:*** *Majority of the patients were >50 years old in both groups. Most of the patients had bilateral lung involvement and ground glass, fibrotic change was the predominant CT pattern in both groups. 64% of non vaccinated patients had consolidation which is significantly higher than the vaccinated group (20%). Non vaccinated patients had more severe disease than vaccinated patients, 84% and 18% respectively. Percentage of lung involvement was significantly higher in non vaccinated group. Vaccinated patients had to stay less number of days (mean 6.2 days) in hospital than non-vaccinated patients (15.24 days). Death rate of non vaccinated (20%) Covid-19 patient was significantly higher than vaccinated (2%) patients.* ***Conclusion:*** *Vaccination can effectively reduce mortality and morbidity of Covid-19 patients by reducing the active number of cases as well as severity of the disease.*

Keywords: *Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), COVID-19, Vaccination.*

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Introduction:

Coronavirus disease 2019 (COVID-19) is a highly infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was firstly reported in Wuhan, Hubei Province, China, and rapidly spreaded to other domestic cities and countries beyond China[1]. On January 30, 2020, the World Health Organization (WHO) declared this ongoing outbreak as a global public health emergency and raised the risk of COVID-19 to very high at the global level on February 28, 2020[2]. Currently there are no specific treatments or vaccines available for COVID-19. However, many ongoing clinical trials evaluating potential treatments[3], and many efforts are done to develop vaccines[4]. Large-scale vaccination of risk groups and later the general population is the single most effective public health measure for mitigation of the coronavirus disease (COVID-19) pandemic[5]. The lack of effective treatment, the severe burden of COVID-19 infection along with its fast spread highlight the need for rapid vaccine development. This

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process was record-breaking, entering human clinical trial testing in March 2020 [4]and by April 2020, more than 100 vaccine candidates were being developed using various methods, five of which were in the clinical evaluation stage and 73 at exploratory or pre-clinical stage [4,6].Bangladesh began the administration of COVID-19 vaccines on 27 January 2021 while mass vaccination started on 7 February 2021[7]. The Oxford–AstraZeneca vaccine was the only COVID-19 vaccine authorized for emergency use from January to April 2021. Bangladesh ordered vaccines produced by Serum Institute of India, however it was not adequate[8]. Chest X-ray (CXR) is generally considered not to be sensitive for the detection of pulmonary abnormalities in the early stage of the disease[9,10] However, in the emergency setting CXR can be a useful diagnostic tool for monitoring the rapid progression of lung involvement in COVID-19, especially in patients admitted to intensive care units[11] Computed tomography (CT) imaging is considered to be the most effective method for detection of lung abnormalities, especially in the early stage of the disease[9,12] Moreover, serial chest CT imaging with different time intervals is also effective in estimating the evolution of the disease from initial diagnosis to discharge from hospital[12,13] RT-PCR is believed to be highly specific, but with sensitivity reported as low as 60-70% and as high as 95- 97%. Thus, false negatives are a real clinical problem[14,15] High resolution Computed tomography (HRCT) of the chest is increasingly recognized as strong evidence for early diagnosis, because the changes in chest imaging sometimes may be earlier than clinical symptoms and thus HRCT scan play an early warning role in the diagnosis of COVID-19[16] Recent studies have demonstrated that HRCT can play a critical role in the early identification of pneumonia and help in accurate diagnosis as HRCT has high sensitivity of 97% in diagnosing COVID-19[17] Radiologic findings, consisting mostly of ground-glass patterns in the lung parenchyma, have been found even among mildly symptomatic persons. Older age, particularly > 60 years, is the strongest risk factor for severe disease and death[18-20]. Li et al. intended to find an objective method to identify significant radiological differences between severe and milder cases of COVID-19 where the overall CT score was the sum of the points from each lobe and ranges from 0 to 25 points[21]. In a study by P. madhu et al. shows Lung involvement are more common in the unvaccinated population, 160(88%) out of 180 members with CTSI showing 3-21, compare with vaccinated group, in which only three members have lung involvement,3(12%) with CTSI:3-8 out of 26 members[22].

This study intends to find out the effectiveness of Covid-19 vaccine by comparing the non vaccinated COVID-19 patient with vaccinated patient by evaluating HRCT scan.

Materials and methods

Type of study:
This was a cross-sectional study.

Place of study:
This study was carried out at the Department of Radiology & Imaging, DNCC dedicated COVID-19 hospital, Mohakhali, Dhaka.

Duration of study: Six month (from April 2021 to September 2021).

Study population:
This prospective study was conducted on 50 (fifty) non vaccinated and fifty (50)vaccinated RT-PCR positive COVID patients irrespective of any age and sex. All the vaccinated patients received 2 doses of Covishield (Oxford AstraZeneca Covid Vaccine). All the study population were admitted into DNCC dedicated Covid-19 hospital. CT Scan was done after 7 days of progression of the disease.

Sampling technique: Purposive sampling.

Selection of patients

Inclusion criteria:

- RT-PCR positive vaccinated and non vaccinated COVID patients having symptoms for atleast 7days.

Exclusion criteria:

- Patients having symptoms less than 7 days.
- Pregnant patients.
- Patients not interested to do CT scan.

Research instruments:
A pre-tested questionnaire.
CT machine.

Data collection technique & study procedure:
This cross-sectional study was conducted on 50 vaccinated and non vaccinated RT-PCR positive COVID patients who were admitted into DNCC dedicated COVID-19 hospital. Informed written consent of the study subjects was taken before undergoing CT scan. Data capturing master sheet was maintained throughout. At enrollment patient's demographic and baseline characteristics was recorded. Computed Tomographic findings were evaluated. Data was collected by a pre-designed proforma. Patient's information was obtained using information sheet which includes questionnaire, clinical and radiological findings.

CT scanning technique
CT was performed for all patients 7 days after onset of symptoms. Scan was done with Philips, Ingenuity ,128-slice CT detector without contrast agent. The scanning parameters were as follows: tube voltage, 120 kVp; tube current, 150 mA; rotation time, 0.8 s; slice thickness, 5 mm; slice interval, 5 mm; pitch, 1.2; matrix, 512 × 512; and breath-holding when fully aspirated.

Image interpretation:
Images were interpreted by two certified radiologists. Severity score was done according to Li et al. (2020) (22). The abnormalities that were considered significant for the disease included the following: groundglass opacity, consolidation, nodule, reticulation, interlobular septal thickening, crazy-paving pattern, bronchial wall thickening, lymph node enlargement, pleural effusion, and pericardial effusion.

Each lobe was awarded a CT score from 0 to 5, depending on the percentage of the involved lobe: score 0 – 0% involvement; score 1 – less than 5% involvement; score 2 – 5% to 25% involvement; score 3 – 26% to 49% involvement; score 4 – 50% to 75% involvement; score 5 – greater than 75% involvement. The overall CT score was the sum of the points from each lobe and ranges from 0 to 25 points.

Upto score 8 was considered as mild disease, score 9-14 was considered as moderate disease and score more than 14 was considered as severe disease.

Statistical analysis:
Statistical analyses were carried out by using the Statistical Package for Social Sciences version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA). A descriptive analysis was performed for all data. The mean values were calculated for continuous variables. The quantitative observations were indicated by frequencies. A "p" value <0.05 was considered as significant.

Ethical consideration:
The aims and objectives of the study along with its procedure, risks and benefits were explained to the respondents in easily understandable local language and then verbal consent was taken from each. It was assured that all information and records would be kept confidential. By following under mentioned steps confidentiality was maintained:

Research data was coded. Data was stored in a locked cabinet. Only research personnel were allowed to access data. There was no physical, psychological, social and legal risk during physical examination. Proper consent was taken. For safeguarding confidentiality and protecting anonymity each of the patients was given a special ID number. A signed informed consent was taken from the patient convincing that privacy of the patient will be maintained and they will be compensated for loss of work time if they want.

Result:

Table I
Distribution of the study patients by age and gender between two groups (n=100)

Parameters	Non vaccinated patients (n=50)		Vaccinated patients (n=50)		P value
Age years(group)	n	%	n	%	
<30	2	4.0	5	10.0	
30-50	20	40.0	21	42.0	
>50	28	56.0	24	48.0	
Mean±SD	51.22±13.71		49.48±15.66		0.556^{ns}
Gender					
Male	25	50.0	32	64.0	0.157^{ns}
Female	25	50.0	18	36.0	

ns=not significant
P value reached from unpaired and Chi square test

Table 1 shows that majority of the patients belonged to age group >50 years in both groups. The mean age was found 51.22±13.71 years in non vaccinated group and 49.48±15.66 years in vaccinated group. Male patients were 25(50.0%) in non vaccinated group and 32(64.0%) in vaccinated group.

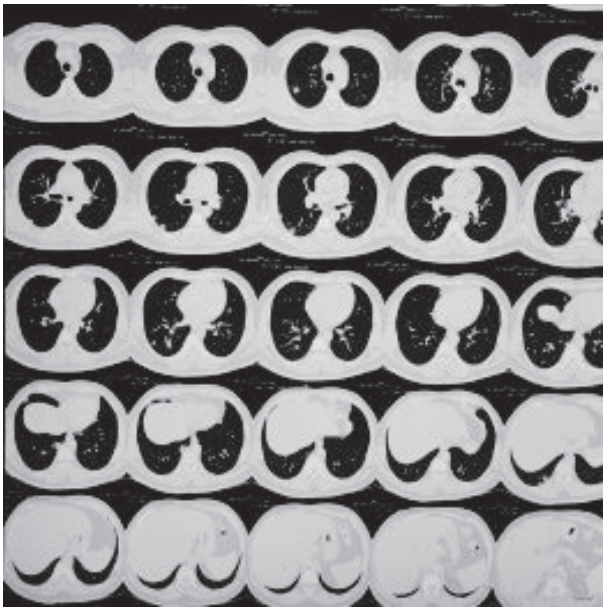

Fig-1. *Axial images of HRCT of chest of a vaccinated Covid-19 patient shows multiple focal areas of ground glass attenuation in both lower lobes. No crazy paving attenuation, consolidation or pleural effusion were noted. The patient had mild disease and recovered.*

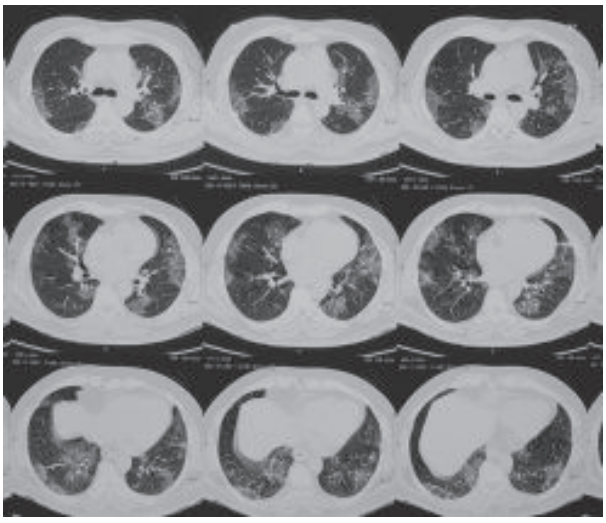

Fig-2. *Axial images of HRCT of chest of a vaccinated Covid-19 patient shows multifocal peripheral ground glass and crazy paving attenuation. No superadded consolidation was noted. The patient was diagnosed as moderate disease.*

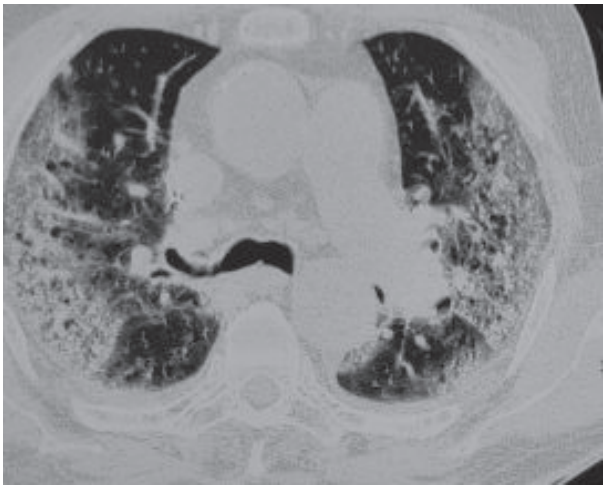

Fig-3. *Axial image of HRCT of chest at the level of tracheal bifurcation of a nonvaccinated Covid-19 patient shows diffuse ground glass attenuation intermixed with septal thickening giving crazy paving appearance and superimposed consolidation, more prominent on peripheral zone. The patient had severe disease.*

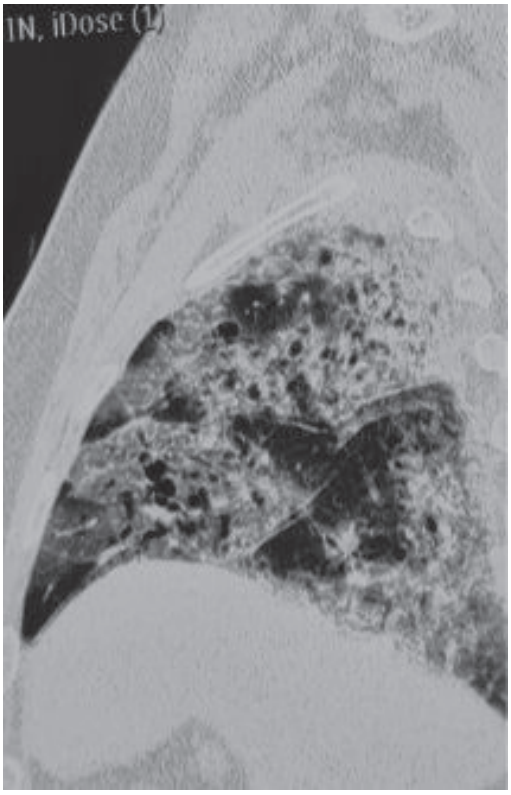

Fig-4. *Reformatted sagittal image of HRCT of chest of a nonvaccinated Covid-19 patient shaows diffuse ground glass attenuation, crazy paving, dilated bronchi and superadded consolidations involving all the lobes. The patient was diagnosed as severe disease.*

Table II

Distribution of the study patients by co-morbidities between two groups (n=100)

Co-morbidities	Non vaccinated patients (n=50)		Vaccinated patients (n=50)		P value
	n	%	n	%	
H/O smoking	9	18.0	13	26.0	0.334^{ns}
DM	8	16.0	15	30.0	0.096^{ns}
HTN	20	40.0	21	42.0	0.893^{ns}
CKD	1	2.0	1	2.0	0.753^{ns}
Obesity	11	22.0	7	14.0	0.298^{ns}

ns=not significant, P value reached from Chi square test

Regarding co-morbidities, history of smoking, DM, HTN, CKD and obesity were not statistically significant (p>0.05) between two groups.

Table III

Distribution of the study patients by side of involvement between two groups (n=100)

Site of involvement	Non vaccinated patients (n=50)		Vaccinated patients (n=50)		P value
	n	%	n	%	
Unilateral	2	4.0	2	4.0	0.382^{ns}
Bilateral	47	94.0	41	82.0	0.065^{ns}

s=significant; ns=not significant, P value reached from Chi square test

Table III shows that 47(94.0%) patients in non-vaccinated group and 41(82.0%) patients in vaccinated group had bilateral involvement.

Table IV

Distribution of the study patients by pattern of density between two groups (n=100)

Pattern of density	Non vaccinated patients (n=50)		Vaccinated patients (n=50)		P value
	n	%	n	%	
Ground glass	47	94.0	36	72.0	0.003^{s}
Nodular	1	2.0	4	8.0	0.181^{ns}
Cray paving	18	36.0	14	28.0	0.391^{ns}
Consolidation	34	68.0	10	20.0	0.001^{s}
Mixed	36	72.0	6	12.0	0.001^{s}

s=significant; ns=not significant, P value reached from Chi square test

Table IV shows that ground glass was significantly higher in non vaccinated group than vaccinated group (94.0% vs 72.0%). Consolidation (68.0% vs 20.0%) and mixed (72.0% vs 12.0%) density was also significantly higher in non vaccinated group than vaccinated group.

Table V

Distribution of the study patients by CT severity scoring on 25 between two groups (n=100)

CT severity scoring on 25	Non vaccinated patients (n=50)		Vaccinated patients (n=50)		P value
	n	%	n	%	
Mild (≤8)	3	6.0	23	46.0	0.001[s]
Moderate (9-14)	4	8.0	11	22.0	0.045[s]
Severe (≥15)	42	84.0	9	18.0	0.001[s]
Normal (0)	1	2.0	7	14.0	0.029[s]

s=significant; ns=not significant, P value reached from Chi square test

Table V shows that mild (≤8) disease was significantly higher in vaccinated group than non-vaccinated group (46.0% vs 6.0%), whereas, severe (≥15) disease was significantly higher in non vaccinated group than vaccinated group (84.0% vs 18.0%).

Table VI

Distribution of the study patients by percentage of lung involvement between two groups (n=100)

Percentage of lung involvement	Non vaccinated patients (n=50)		Vaccinated patients (n=50)		P value
	n	%	n	%	
0-4	1	2.0	7	14.0	0.029[s]
5-25	4	8.0	19	38.0	0.001[s]
26-49	6	12.0	11	22.0	0.156[ns]
50-75	29	58.0	10	20.0	0.001[s]
>75	10	20.0	3	6.0	0.037[s]

s=significant; ns=not significant, P value reached from Chi square test

Table VI shows that non vaccinated patient had significantly more percentage of lung involvement than vaccinated patient.

Table VII

Distribution of the study patients by hospital stay between two groups (n=100)

	Non vaccinated patients (n=50) Mean ±SD	Vaccinated patients (n=50) Mean ±SD	P value
Hospital stay (day)	15.24 ±5.21	6.20 ±4.51	0.001[s]

s=significant, P value reached from unpaired t-test

Table VII shows that mean hospital stay was 15.24±5.21 days in non vaccinated group and 6.20±4.51 days in vaccinated group.

Table VIII

Distribution of the study patients by outcome between two groups (n=100)

Outcome	Non vaccinated patients (n=50)		Vaccinated patients (n=50)		P value
	n	%	n	%	
Death	10	20.0	1	2.0	0.001[s]
Alive	40	80.0	49	98.0	

s=significant, P value reached from Chi square test

Table VIII shows that death patients were significantly higher in non vaccinated group than vaccinated group (20.0% vs 2.0%)

Discussion:

This cross-sectional study was carried out with an aim to evaluate the effectiveness of COVID-19 vaccine by studying and comparing the post CT scan findings of both vaccinated and non vaccinated RT-PCR positive Covid-19 patients. A total of 50 non vaccinated and 50 vaccinated RT-PCR positive Covid-19 patients were studied by CT scan to evaluate the severity of the disease of both groups. All the vaccinated patients received 2 doses of Covishield (Oxford AstraZeneca Covid Vaccine). CT Scan was done after 7 days of progression of the disease.

In our study it was observed that incidence of Covid-19 was higher in older (more than 50 years) population in both vaccinated (48.0%) and non vaccinated (56.0%) groups. Mean age of non vaccinated group was 51.22±13.71 and vaccinated group was 49.48±15.66.

In this study no significant gender discrimination was observed in non-vaccinated Covid-19 patients. 50% patient were male and 50% were female. While male predominance was seen in vaccinated Covid-19 patients. 64% patients were male.

In our study 18% of the non-vaccinated patients were smoker, while 26% patients vaccinated patient were smoker. Hypertension was the most frequent risk factor in both groups (40% in non vaccinated and 42% in vaccinated patients) followed by obesity (22%) & DM (16%) in non-vaccinated group and DM (30%) & obesity (14%) in vaccinated group.

Regarding lung involvement in CT scan 94% of non vaccinated patient and 82% of vaccinated patient had bilateral lung involvement.

More than one lobe involvement was more evident in non vaccinated covid-19 patients.

It was observed that ground glass was the predominant CT pattern in both groups, respectively 94% and 72% in non-vaccinated and vaccinated patient. 36% of non vaccinated and 28% of vaccinated patient had crazy paving pattern in CT scan. It was noted that 64% of vaccinated patient had consolidation which is significantly higher than the vaccinated group (20%). P value was less than .05. So disease progression was less evident in case of vaccinated patient. More than one pattern was more frequently observed in non vaccinated patients.

CT severity Score is a very important prognostic factor for Covid-19 patients. In this study it was observed that non vaccinated patients had more severe disease than vaccinated patient, 84% and 18% respectively. P value was <.05. Most of the vaccinated Covid-19 (46.0%) patients had mild disease which is significantly higher than non vaccinated Covid-19 patient (6%). However it was noted that vaccinated Covid-19 patient had more percentage (22%) of moderate disease than non-vaccinated patient (8%).

Percentage of lung involvement in a strong predictor of prognosis and progression of the disease. It was observed that percentage of lung involvement was significantly higher in non vaccinated group. 58% of the patients had 50-75 % and 20% patients had more than 75% of total lung involvement. This numbers were significantly lower in vaccinated group involving 20% and 6% of patients respectively. Percentage of lung involvement was lower in vaccinated group involving less than 25% of total lung field in more than 50% of cases.

Regarding hospital stay it was noted that on average vaccinated patients had to stay less number of days (mean 6.2 days) in hospital than non-vaccinated patients (15.24 days). P value was less than .05.

Death rate of non-vaccinated Covid-19 patient was significantly higher than vaccinated patients. 20% (10) of non vaccinated Covid-19 patients died after admitting into our hospital. While 2% (01) of patients died from the vaccinated group.

Conclusion

Vaccination can become one of the most important factors for eradicating ongoing Covid-19 pandemic. It not only minimizes the health hazards but also reduces the total length of hospital stay, hence helps the patients to lower the financial burden. It is very satisfying that Bangladesh has already taken the initiatives for mass vaccination. In our study we found that vaccination can effectively reduce mortality and morbidity of Covid-19 patients. In a developing country like Bangladesh it is very important to eradicate Covid-19 as early as possible to ensure social and financial stability. Effective mass vaccination can play a pivotal role in this situation by reducing the active number of cases as well as severity of the disease.

References:

1. Zhu N, Zhang D, Wang W et al (2020) A novel coronavirus from patients with pneumonia in China. *N Engl J Med* 2019. https://doi. org/10.1056/NEJMoa2001017.
2. World Health Organization Coronavirus disease 2019 (COVID-19) situation report–39. 2020. World Health Organization, Geneva. Available via https://www.who.int/docs/default-source/coronavirus/situation-reports/20200228-sitrep-39-covid-19.pdf?sfvrsn=5bbf3e7d_2. Accessed 3 Mar 2020.
3. World Health Organization. Coronavirus. https://www.who.int/health-topics/coronavirus #tab=tab_1. Accessed June 6, 2020.
4. Thanh Le T, Andreadakis Z, Kumar A, Gómez Román R, Tollefsen S, Saville M & Mayhew S. The COVID 19 vaccine development landscape. *Nature Reviews Drug Discovery* 2020;19(5), 305–306.
4. Dooling K, McClung N, Chamberland M, Marin M, Wallace M, Bell BP, Lee GM, Talbot HK, Romero JR, Oliver SE. The Advisory Committee on Immunization Practices' interim recommendation for allocating initial supplies of COVID-19 vaccine—United States, 2020. *Morbidity and mortality weekly report* 2020; Dec 11;69(49):1857.
5. World Health Organization. (WHO). Draft landscape and tracker of COVID-19 candidate vaccines. [cited 2021 Feb 17]. Available from: https://www.who.int/publications/m/item/draft-landscape-of-covid19-candidate-vaccines
7. "Bangladesh starts COVID vaccination drive use". *Al Jazeera. 28 January 2021*. Retrieved 30 April 2021
8. Covid-19: Why the crisis in vaccines? use". *Prothom Alo. 29 April 2021*. Retrieved 30 April 2021.
9. Zu ZY, Jiang MD, Xu PP, Chen W, Ni QQ, Lu GM, Zhang LJ. Coronavirus disease 2019 (COVID-19): a perspective from China. *Radiology* 2020; Aug;296(2): E15-25.
10. Ming-Yen N, Lee Elaine YP, Jin Y, Fangfang Y, Xia L, Hongxia W, Mei-sze LM, Shing-Yen LC, Barry L, Pek-Lan K, Kim-Ming HC. Imaging profile of the COVID-19 infection: radiologic findings and literature review. *Radiology: Cardiothoracic Imaging* 2020; 2(1): e200034.
11. Borghesi A, Maroldi R. COVID-19 outbreak in Italy: experimental chest X-ray scoring system for quantifying and monitoring disease progression. *La radiologia medica* 2020; May;125(5):509-13.
12. Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, Diao K, Lin B, Zhu X, Li K, Li S. Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection. *Radiology* 2020; Feb 20:200463.
13. Pan F, Ye T, Sun P, Gui S, Liang B, Li L, Zheng D, Wang J, Hesketh RL, Yang L, Zheng C. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. *Radiology* 2020, Feb 13.
14. Lei J, Li J, Li X, Qi X. CT imaging of the 2019 novel coronavirus (2019-nCoV) pneumonia. *Radiology* 2020; Apr;295(1):18-20.
15. Cheng Z, Lu Y, Cao Q, Qin L, Pan Z, Yan F, Yang W. Clinical features and chest CT manifestations of coronavirus disease 2019 (COVID-19) in a single-center study in Shanghai, China. *American Journal of Roentgenology* 2020; Jul;215(1):121-6.
16. Wang H, Wei R, Rao G, Zhu J, Song B. Characteristic CT findings distinguishing 2019 novel coronavirus disease (COVID-19) from influenza pneumonia. *European radiology* 2020; Sep;30(9):4910-7.
17. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, Xia L. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. *Radiology* 2020; Aug;296(2): E32-40.
18. Lu L, Zhong W, Bian Z, Li Z, Zhang K, Liang B, Zhong Y, Hu M, Lin L, Liu J, Lin X. A comparison of mortality-related risk factors of COVID-19, SARS, and MERS: A systematic review and meta-analysis. *Journal of Infection* 2020; Jul 4.

19. Noor FM, Islam MM. Prevalence and associated risk factors of mortality among COVID-19 patients: a meta-analysis. *Journal of community health* 2020; Dec;45(6):1270-82.

20. Kumar A, Arora A, Sharma P, Anikhindi SA, Bansal N, Singla V, Khare S, Srivastava A. Clinical features of COVID-19 and factors associated with severe clinical course: a systematic review and meta-analysis. Social Science Research Network. 2020 Apr.

21. Li K, Wu J, Wu F, Guo D, Chen L, Fang Z, Li C. The clinical and chest CT features associated with severe and critical COVID-19 pneumonia. *Investigative radiology* 2020.

22. Madhu P, Santhosh D, Madhala K. Comparison Study of Lung Involvement in Vaccinated and Un Vaccinated Covid Patients. *International Journal of Health and Clinical Research* 2021; May 27;4(10):229-33.