



# Pulmonary radiologic findings based on Warrick score as a predictor of COVID-19 patients' outcomes

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## Abstract

**Introduction:** Predicting factors related to the severity and mortality of coronavirus disease 2019 (COVID-19) patients can significantly help in better management of their treatment.

**Objectives:** This study aimed to investigate the correlation between pulmonary radiologic findings based on the Warrick score and COVID-19 patients' outcomes.

**Patients and Methods:** This descriptive-analytical study was conducted on 436 COVID-19 patients hospitalized at Shahid Mohammadi hospital in Bandar Abbas. Pulmonary radiologic findings were scored based on the Warrick score. Outcomes of COVID-19 patients, including disease severity and mortality, were followed. Independent T-test and binary logistic regression were conducted to explore the correlation between the pulmonary radiologic findings and patients' outcomes.

**Results:** Results showed that the correlation between pulmonary radiologic findings with both disease severity and mortality was significant, since higher pulmonary involvement caused greater severity and mortality. The Warrick score difference between dead and recovered patients and low and high disease severity were significant, therefore greater Warrick score caused more disease severity and mortality.

**Conclusion:** Pulmonary radiologic findings based on the Warrick score can use as a predictor of COVID-19 patients' outcomes.

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## Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) appeared in Wuhan, China, for the first time in December 2019 (1). World Health Organization (WHO) on February 11, 2020, named it coronavirus disease 2019 (COVID-19) (2). This viral disease widely affected the world health system due to easy human-to-human transmission (3) and showed various symptoms, including fever, cough, fatigue, body ache, dyspnea, sputum, headache, diarrhea, vomiting, and pulmonary involvement in the chest CT scan (1). Despite the various clinical symptoms, several studies have mentioned, dyspnea and pulmonary involvement as the most common symptoms of this disease (4-6).

Computed tomography (CT) scan is one of the best and most accessible tools for predicting COVID-19 outcomes (7). Warrick score is

## Key point

Warrick CT score positively is correlated with COVID-19 patients' outcomes, including disease severity and mortality. A Warrick score of more than 15 is a powerful predictor of COVID-19 disease severity and mortality. Greater pulmonary involvement findings due to greater Warrick scores are associated with COVID-19 patients' outcomes, such as disease severity and mortality.

a scale based on observed parenchymal pathology and the extent of lesions in lung CT scans. This scale is based on the pulmonary involvement severity and extent, which can be different ranged alveolitis to fibrosis (8). In this study, we investigated the correlation of pulmonary radiologic findings based on the Warrick score with the COVID-19 patients' outcomes.



## Objectives

Predicting factors related to the severity and mortality of COVID-19 patients can significantly help in better management of their treatment. This study aimed to investigate the association of pulmonary radiologic findings based on the Warrick score with the COVID-19 patients' severity and mortality.

## Patients and Methods

### Study design and participants

This descriptive-analytical study was conducted on 436 COVID-19 patients hospitalized at Shahid Mohammadi hospital in Bandar Abbas, Iran, from May 2021 to June 2022. Patients with a definite diagnosis of COVID-19 based on positive real-time polymerase chain reaction (RT-PCR) or chest CT scans were included in this study. Demographic characteristics were collected by demographic questionnaire. The high disease severity of COVID-19 was defined as the need for mechanical ventilation or being hospitalized in the intensive care unit (ICU). Low-disease severity was defined as no need for mechanical ventilation or hospitalization in the general ward. Outcomes (death/recovery) of patients were followed. Pulmonary involvement in chest CT scans was scored by the Warrick scale. The correlation of pulmonary radiologic findings based on the Warrick score with the severity and mortality of COVID-19 disease was assessed.

### Radiological evaluation and Warrick scale

Chest CT scans were taken for all patients, and pulmonary involvement was scored by the Warrick scale. This scale was scored based on parenchymal pathology and the extent of lesions in the lung CT scans. The total score was calculated based on pulmonary involvement severity and extent, which can be different ranged alveolitis to fibrosis. The total Warrick score was scaled ranges 0 to 30, and a higher score indicates more pulmonary involvement. Warrick score consists of two alveolitis and fibrosis indexes. The alveolitis index included the existence and extent of ground glass opacities and it has a score range of 0 to 4. The fibrosis index included irregularities in pleural margins, septal/sub-pleural lines, honeycombing appearance, and sub-pleural cysts and their extent, and it has a score range of 0 to 26. Warrick score is calculated of alveolitis index plus fibrosis index and ranges from 0 to 30. A Warrick score of less than 15 is considered mild pulmonary radiologic findings, and a Warrick score of more than 15 is considered severe (8).

### Statistical analysis

Data were analyzed by Statistical Package for the Social Sciences (SPSS) version 26. Descriptive tests such as mean, variance, and standard deviation, and analytical tests such as Mann-Whitney U test and binary logistic regression were used to analyze the correlation between pulmonary radiologic findings based on the Warrick score with

the COVID-19 disease severity and mortality. For data normality, the Kolmogorov-Smirnov test was conducted. A *P* value less than 0.05 were considered significant.

## Results

Results showed that out of 436 patients, 257 (58.9%) were male, and 179 (41.1%) were female, with a mean age of  $62.06 \pm 17.98$  years. Pulmonary radiologic findings in most of the patients were severe. Most of them were non-intubation, 102 (23.4%) died, and 334 (76.6%) got recovery (Table 1).

Results demonstrated that most of participating samples in the study had symptoms of fever, dyspnea, weakness, body ache, and headache (Table 2).

Results showed that out of 102 dead patients 19 had mild pulmonary radiologic findings and 83 had severe. Among 334 people who got recovery, 170 had mild pulmonary radiologic findings, and 164 had severe pulmonary radiologic findings. Logistic regression showed that the correlation between mortality and pulmonary radiologic findings was significant, therefore the higher severe pulmonary radiologic findings caused more death. Among 299 patients who were non-intubation, 150 had mild pulmonary radiologic findings, and 149 had severe. Out of 137 patients who were intubated, 40 had mild pulmonary radiologic findings, and 97 had severe. Binary logistic regression demonstrated that pulmonary radiologic findings were correlated with COVID-19 disease severity, thereby the patients who had more severe pulmonary radiologic findings were more intubated (Table 3).

The mean Warrick score in dead patients was 20.54, and in the recovered was 16.26. Mann-Whitney U test showed that the Warrick score difference between dead and recovered patients was significant therefore greater Warrick score was associated with more death. In the non-intubated patients mean Warrick score was 16.36 and in the intubated was 19.18. Mann-Whitney U test showed

**Table 1.** Demographic characteristics, pulmonary radiologic findings, disease severity, and mortality of participating samples in the study

Variables	No.	%
Gender		
Male	257	58.9
Female	179	41.1
Disease severity		
Not intubation	229	68.6
Intubation	137	31.4
Mortality		
Death	102	23.4
Recovery	334	76.6
Pulmonary radiologic findings		
Mild	189	43.3
Severe	247	56.7
	<b>Mean</b>	<b>Standard deviation</b>
Age (y)	62.06	17.98

**Table 2.** The most common symptom of participating samples in the study

Symptoms	Frequency	Percent
<b>Fever</b>		
Yes	320	73.4
No	116	26.6
<b>Dyspnea</b>		
Yes	357	81.9
No	79	18.1
<b>Weakness</b>		
Yes	248	56.9
No	188	43.1
<b>Body ache</b>		
Yes	277	63.5
No	159	36.5
<b>Headache</b>		
Yes	104	23.9
No	332	76.1

that the Warrick score difference between intubation and non-intubation patients was significant, therefore the higher Warrick score caused more intubation (Table 4).

### Discussion

Pulmonary radiology findings can play a key role in the prognosis of COVID-19 patients (7). The result of the present study showed that high pulmonary involvement based on the higher Warrick score was associated with higher disease severity and more mortality in COVID-19 patients. In line with our study, Francone et al reported that CT score is related to COVID-19 patients' outcomes and can be a predictor of COVID-19 patients' severity and mortality (9). Li et al stated that higher chest CT scores are correlated with risk factors for COVID-19 patients' mortality and disease severity (10). The Warrick scale was scored based on parenchymal pathology and the extent of

lesions in the lung CT scans (8). Greater Warrick scores indicate more lung involvement and greater pulmonary involvement caused more disease severity and, as a result, higher mortality of patients. COVID-19 virus is more likely to affect the lung, and involvement lungs can't be able to exchange blood gas, and, as a result, patients die because of dyspnea.

In our study, when we divided the Warrick score into two groups of less than 15 as mild pulmonary involvement finding and more than 15 as severe pulmonary involvement finding, results showed that pulmonary involvement is correlated with more COVID-19 patients' death and disease severity. Consistent with these findings, Lei et al stated that high lung involvement and diffuse distribution of lung lesions in chest CT of COVID-19 patients correlate with disease severity and mortality (11). Xie et al highlighted that the chest CT involvement score could be a helpful tool for evaluating COVID-19 patients' outcomes (12). Hu et al found a moderate positive correlation between chest CT findings and COVID-19 patients' outcomes, while worse CT findings have been seen in patients who died cause of COVID-19 disease (13).

Previous studies demonstrated that CT scan has several different roles in COVID-19 disease prognosis. A previous study showed that a chest CT scan plays an essential role in the early diagnosis of COVID-19 pneumonia and the assessment of the severity of pulmonary involvement (14). Another study stated that a chest CT scan could provide prognostic information about progression to the severe stage (15). The findings of this study showed that a chest CT scan could be an efficient tool for classifying the prognosis of COVID-19 patients. Evaluating patient outcomes using such results can lead to more effective management of COVID-19 infection.

**Table 3.** Assessment of the correlation between COVID-19 disease severity and mortality with pulmonary radiologic findings

Pulmonary radiologic findings	Total cases	Mild	Severe	Odds ratio	95% CI (Lower–Upper)	P value
	Frequency n=436	No. (%) (n=189)	No. (%) (n=247)			
<b>Mortality</b>						
Death	102	19 (18.6)	83 (81.4)	4.52	2.632–7.791	<0.001*
Recovery	334	170 (50.9)	164 (49.1)			
<b>Severity</b>						
Non- Intubation	299	149 (49.8)	150 (50.2)	2.40	1.563–3.712	<0.001*
Intubation	137	40 (29.2)	97 (70.8)			

\*Binary logistic regression.

**Table 4.** Comparison of the Warrick score between two groups of death and recovery, and intubation and non-intubation patients

Variable		Warrick score		P value
		Mean	Standard deviation	
Mortality	Death	20.54	4.79	< 0.001*
	Recovery	16.26	9.47	
Disease severity	Non-intubation	16.39	6.56	0.002*
	Intubation	19.18	5.51	

\*Mann-Whitney U.

## Conclusion

Pulmonary radiologic findings based on the Warrick score are associated with COVID-19 patients' outcomes, and it is possible to conduct it as a predictor tool for predicting COVID-19 disease prognoses such as recovery, disease severity, and mortality.

## Limitations of the study

Due to the being a retrospective study, the incompleteness of the information in the clinical patients' documents was one of the considerable study limitations. Individual, social, psychological, and family differences were uncontrollable variables of the present study that can affect the research results.

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## Authors' contribution

Conceptualization; MB and SA.

Methodology: MS.

Validation: EZ.

Formal analysis: FZ.

Investigation: GA and AZ.

Resources: AK, MB and FG.

Data curation: MB and AZ.

Writing—original draft preparation: ZT, SA, MS and AK.

Writing — review and editing: AK, MB, ZT FZ and EZ.

Visualization: AZ.

Supervision: FG.

Project administration: MB.

## Conflicts of interest

The authors declare that there is no conflict of interest.

## Ethical issues

The research followed the tenets of the Declaration of Helsinki. The Ethics Committee of Hormozgan University of Medical Sciences approved this study (Ethical code #IR.HUMS.REC.1400.008). This study was extracted from a research project at Hormozgan University of Medical Sciences. Accordingly, written informed consent was taken from all participants before any intervention. Besides, the authors have ultimately observed ethical issues (including plagiarism, data fabrication, and double publication).

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