The Predictors of COVID-19 Disease Outcomes in Health Care Workers

Ali Monfared
Urology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Ali Hamidi Madani
Urology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Morteza Rahbar Taromsari
Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Masoud Khosravi
Urology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Seyed Mahmoud Rezvani
School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Aydin Pourkazemi
Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Pegah Aghajanzadeh
Urology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Neda Akhondzadeh
Clinical Research Development Unit of Poursina Hospital, Guilan University of Medical Sciences, Rasht, Iran
Aboozar Fakhr-Mousavi
Cardiovascular Diseases Research Center, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Mostafa Saeedinia
Anesthesiology Research Center, Department of Anesthesiology, Alzahra Hospital, Guilan University of Medical Sciences, Rasht, Iran
Ali Faghih Habibi
Otorhinolaryngology Research Center, Department of Otolaryngology and Head and Neck Surgery, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Mohammad Hasan Vakilzadeh
Guilan University of Medical Sciences, Rasht, Iran
Seyed Ali Alavi Foumani
Lung Diseases Research Center, Department of Internal Medicine, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Alireza Jafarinejad
Lung Diseases Research Center, Department of Internal Medicine, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Azita Tangestaninejad
Lung Diseases Research Center, Department of Internal Medicine, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Cyrus Gharib
Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Irandokht Shenavar
Rheumatology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sci-ences, Rasht, Iran
Heidar Ali Baluo
Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Hossein Hemmati
Razi Clinical Research Development Unit, Guilan University of Medical Sciences, Rasht, Iran
Abtin Heidarzadeh
Razi Clinical Research Development Unit, Guilan University of Medical Sciences, Rasht, Iran
Ali Mohammadzadeh Jouryabi
Anesthesiology Research Center, Department of Anesthesiology, Alzahra Hospital, Guilan University of Medical Sciences, Rasht, Iran
Siamak Rimaz
Anesthesiology Research Center, Department of Anesthesiology, Alzahra Hospital, Guilan University of Medical Sciences, Rasht, Iran
Mohammad Haghighi
Anesthesiology Research Center, Department of Anesthesiology, Alzahra Hospital, Guilan University of Medical Sciences, Rasht, Iran
Bahram Naderi-Nabi
Anesthesiology Research Center, Department of Anesthesiology, Alzahra Hospital, Guilan University of Medical Sciences, Rasht, Iran
Samaneh Esmaeili
Urology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
Leila Akhondzadeh (leilaakhondzadeh@gmail.com)
Urology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran

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Abstract

Introduction: The COVID-19 has been associated with many problems for the general public and especially health care workers (HCWs). This study conducted to provide predictors of COVID-19 outcomes on HCWs in Rasht, Iran.

Methods: In a retrospective cross-sectional study, 381 HCWs with positive RT-PCR or high-resolution lungs computed tomography for COVID-19 from February 21 to April 19, 2020 evaluated. The prevalence, demographic, clinical, laboratory, and radiological presentations and outcomes and their correlation were studied.

Results: The prevalence of COVID-19 in HCWs was 5.62%, and the total mortality rate was 0.2%. The mortality rates were different between genders (*P*=0.002) and in general ward compared to intensive care unit (*P*=0.001). In the multivariate analysis, age (OR:1.12, 95%CI 1.02–1.23, *P*=0.014), diabetes mellitus (DM) (OR:10.73, 95%CI 1.91–60.3, *P*=0.007), blood group B (OR:19.2, 95%CI 1.8–199.984, *P*=0.013), the presence of peribronchovascular involvement (OR:1.1, 95% CI OR:1.02–1.2, *P*=0.019), dyspnea on admission (OR:1.05, 95%CI 1.01–1.09, *P*=0.013), higher neutrophil count (OR:1.09, 95%CI 1.04–1.14, *P*<0.001), higher level of alkaline phosphatase (OR:1, 95%CI 1.001–1.002, *P*=0.001), and longer prothrombin time (OR:1.027, 95%CI 1.008–1.046, *P*=0.005) increase the risk of mortality. The cutoff of 90% for oxygen saturation on admission (sensitivity=91.9%, specificity=88.9%) and 1004 for absolute lymphocyte count (sensitivity=81.8%, specificity=66.6%) were estimated as predictors of mortality.

Conclusions: Old age, male sex, underlying disease of DM and hypertension, O_2 saturation less than 90%, and absolute lymphocyte count less than 1004/mL in HCWs are prone to adverse outcomes such as the need for mechanical ventilation or death.

Introduction

The outbreak of COVID-19 caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first reported in Wuhan, China, in December 2019 (1–2).

On March 11, the World Health Organization (WHO) declared it a pandemic (3).

Iran reported its first confirmed case on February 19, 2020. The Guilan Province in the north of Iran reported its first cases on February 21 (3).

Various methods such as physical distancing, face mask, and even quarantine have been used to control the pandemic, but, unfortunately, due to the lack of uniform and simultaneous application of these methods in different countries so far, measures taken to prevent the worldwide spread of the virus has not been completely successful, and millions of persons have been affected with a mortality rate of 3% in more than 180 countries (1–5).

SARS-CoV-2 infection in health care workers (HCWs) is practically unavoidable due to the high infectivity of the virus and its respiratory transmission from symptomatic, pre-symptomatic, and asymptomatic individuals, and because they are at the forefront of the fight against COVID-19, so they are at higher risk of developing COVID-19 and transmitting it to patients and others (6–10).

Although today there is a wealth of information about the prevalence of COVID-19 in HCWs in different conditions, it is not clear whether the clinical features and consequences of COVID-19 in HCWs differ from those of the general population. HCWs, due to constant exposure to the virus, may receive a higher load of the virus and may have worse clinical outcomes (6).

In early reports from Wuhan, China, 29% of diagnosed COVID-19 patients were HCWs (10). Thus, there are various constraints in designing effective ways to prevent the transmission of the virus in the hospital and from the hospital to the community. As a result, evaluation of the characteristics of COVID-19 infection in HCWs may play an important role in controlling the pandemic (6).

According to this, we designed a study to evaluate the clinical, laboratory, and radiological presentations, outcomes, and related risk factors of this disease in HCWs in Rasht, the center of Guilan.

Methods

Study design

Our retrospective cross-sectional survey was conducted from February 21, 2020 (the start of the COVID-19 pandemic in Iran) to April 19, 2020. We performed the study involving 10 Rasht hospitals and the Rasht Health Centre.

The HCWs of Rasht who experienced symptoms of viral infections such as fever, chills, coughing, shortness of breath, headache, sore throat, and myalgia during February, and April 2020 were studied.

The list of those who had been hospitalized or on leave due to COVID-19 during these two months was extracted from the Rasht Health Centre and the Hospital Nursing Offices in these 10 hospitals. HCWs working in hospitals and health care centers were informed about this study.

HCWs who had undergone the positive reverse-transcriptase–polymerase chain reaction (RT-PCR) test for SARS-CoV-2 infection of the nasopharynx/oropharynx or a high-resolution computed tomography (HRCT) of the lungs recommended for COVID-19 pneumonia or both were enrolled in this study. The HRCTs of the lungs and the COVID-19 characteristics were confirmed by radiologists. Due to limited access to COVID-19 RT-PCR testing, we were unable to perform this test for all symptomatic staff.

Demographic information of patients, type of personal protective equipment (PPE), early symptoms, medical history, drug history, smoking status, vital signs at admission (in the case of hospitalized patients), laboratory data, imaging, type of respiratory support, length of hospital stay, and outcomes were collected.

In the cases where they were hospitalized, their medical documentation was the source of data, and in those cases who were managed as an outpatient, they were called over the phone to gather the necessary information.

Each of the authors of this article was responsible for data collection at the designated hospitals and health care centers.

Outcome measures

The outcomes of the disease include discharge from the hospital, invasive mechanical ventilation, and death.

Ethics committee approval

We did not get written informed consent. There were cases where informed consent was obtained verbally on call or by contacting the families in expired cases.

The Ethics Committee of the Guilan University of Medical Sciences, Iran, approved the project (IR.GUMS.REC.1399.027), and the study was carried out following the Guidelines on Good Clinical Practice and the Helsinki Declaration.

Statistical analysis

Data were analyzed using the SPSS version 24 software. Quantitative data were described using mean, standard deviation, and median, and qualitative data were described using frequency and percentage. Quantitative variables were compared using an independent *t*-test, and if the distribution of data was not normal, the Mann–Whitney U test was used. Chi-square and Fisher tests were used to compare qualitative variables. For multivariate analysis to determine the outcome predictors, we applied a multivariate logistic model with the backward logistic regression method. The statistically significant level was considered less than 0.05.

Results

Demographic characteristics and outcome

Of all HCWs (6775), including 4383 (64.69%) females and 2392 (35.3%) males, 522 (7.75%) of them were symptomatic during the period from February 21, 2020, to April 19, 2020. A total of 381 (72.98%) symptomatic individuals fulfilled the inclusion criteria and were enrolled in this study. A total of 251 (65.8%) of them were outpatient cases and 130 (34.1%) inpatient. Out of 130 hospitalized patients, 56 (43%) were admitted to the ICU and 74 (56%) to the general COVID-19 ward.

Overall, the prevalence of COVID-19 in HCWs was 5.62% (381/6775), and in symptomatic patients, it reached 72.98% (381/522), and the mortality rate was 0.2% (14/6775) in total, 3.6% (14/381) in confirmed cases and 10.7% (14/130) in hospitalized patients.

A total of 5.29% of females (232/4383) and 6.2% of males (149/2392) were infected with COVID-19. The mortality in infected females was 1.2% (3/232) and 7.3% (11/149) in males. There is a statistically significant difference between the mortality rates in males and females ($P = 0.002$).

The pattern and correlation of age, gender, and mechanical ventilation (MV) with mortality, $P < 0.001$, $P < 0.001$and $P = 0.002$, $P = 0.002$, respectively, are shown in Table 1.

Table 1
The relation between baseline characteristics of HCP with outcomes of Covid-19

Outcome							
		Discharge	Death	P	Without invasive mechanical ventilation	With invasive mechanical ventilation	P
Age group	20-29yr	100.0%(43/43)	0.0%	<0.001	100.0%(43/43)	0.0%	<0.001
	30-39yr	100.0%(112/112)	0.0%		100.0%(112/11)	0.0%	
	40-49yr	96.0%(121/126)	4.0%(5/126)		96.8%(122/12)	3.2%(4/126)	
	50-59yr	94.9%(74/78)	5.1%(4/78)		96.2%(75/78)	3.8%(3/78)	
	≥60yr	73.7%(14/19)	26.3%(5/19)		78.9%(15/19)	21.1%(4/19)	
Age		41.93±10.13(20.00 -83.00)	56.07±11.27(43.00-80.00)	<0.001	42.10±10.32(20.00-83.00)	54.27±10.10(43.00-71.00)	<0.001
Sex	Male	92.6%(138/149)	7.4%(11/149)	0.002	94.0%(140/14)	6.0%(9/149)	0.002
	Female	98.7%(229/232)	1.3%(3/232)		99.1%(230/23)	0.9%(2/232)	
BMI*		26.39±4.19(17.69-42.97)	27.84±2.63(22.77-31.20)	0.278	26.42±4.19(17.69-42.97)	27.01±2.52(22.77-30.86)	0.691
Job category	Doctor	90.6%(58/64)	9.4%(6/64)	0.26	92.2%(59/64)	7.8%(5/64)	0.19
	Nurse	97.1%(170/175)	2.9%(5/175)		98.3%(172/17)	1.7%(3/175)	
	Administrative staff	97.3%(73/75)	2.7%(2/75)		97.3%(73/75)	2.7%(2/75)	
	Midwife	100.0%(8/8)	0.0%		100.0%(8/8)	0.0%	
	Security & service personnel	97.4%(37/38)	2.6%(1/38)		97.4%(37/38)	2.6%(1/38)	
	Anesthesia/operating room technician	100.0%(8/8)	0.0%		100.0%(8/8)	0.0%	
	Laboratory staff	100.0%(10/10)	0.0%		100.0%(10/1)	0.0%	
Workplace	Administration	98.3%(116/118)	1.7%(2/118)	0.1	99.2%(117/11)	0.8%(1/118)	0.13
	Emergency ward	94.1%(16/17)	5.9%(1/17)		100.0%(17/1)	0.0%	
	Covid-19 ward	94.7%(144/152)	5.3%(8/152)		94.7%(144/15)	5.3%(8/152)	
	ICU**	100.0%(39/39)	0.0%		100.0%(39/3)	0.0%	
	Radiology/laboratory units	95.7%(22/23)	4.3%(1/23)		95.7%(22/23)	4.3%(1/23)	
	Service staff	100.0%(12/12)	0.0%		100.0%(12/12)	0.0%	
	Operation room	86.7%(13/15)	13.3%(2/15)		93.3%(14/15)	6.7%(1/15)	
	Security department	100.0%(2/2)	0.0%		100.0%(2/2)	0.0%	
Place of hospitalization	ICU	92.9%(52/56)	7.1%(4/56)	0.001	92.9%(52/56)	7.1%(4/56)	0.001
	Covid-19 ward	89.2%(66/74)	10.8%(8/74)		93.2%(69/74)	6.8%(5/74)	
	Outpatient	99.2%(249/251)	0.8%(2/251)		99.2%(249/25)	0.8%(2/251)	
Systolic blood pressure on admission	Mean	113.14	125.38	0.039	113.59	120.00	0.517
Diastolic blood pressure on admission	Mean	69.35	76.67	0.085	69.56	74.44	0.613
Respiratory rate on admission	Mean	22.96	31.31	0.054	23.02	32.70	0.043
Oxygen saturation	Mean	94.35	84.25	<0.001	94.23	84.80	<0.001

*BMI-body mass index

**ICU-intensive care unit

Outcome							
Body temperature on admission	Mean	38.04	38.42	0.202	38.04	38.53	0.121
Blood groups(A,B,AB,O)	A	94.1%(64/68)	5.9%(4/68)	0.05	95.6%(65/68)	4.4%(3/68)	0.05
	B	88.7%(55/62)	11.3%(7/62)		90.3%(56/62)	9.7%(6/62)	
	AB	100.0%(15/15)	0.0%		100.0%(15/15)	0.0%	
	O	97.3%(110/113)	2.7%(3/113)		98.2%(111/11)	1.8%(2/113)	
Rhesus system(Rh)	Rh+	94.9%(222/234)	5.1%(12/234)	0.381	96.2%(225/23)	3.8%(9/234)	0.272
	Rh-	91.7%(22/24)	8.3%(2/24)		91.7%(22/24)	8.3%(2/24)	
*BMI-body mass index							
**ICU-intensive care unit							

In terms of the hospitalization site and its relationship with outcomes, patients admitted to the general COVID-19 ward had higher mortality of 10.8% (8/74) ($P = 0.001$) and less MV of 6.8% (5/74) ($P = 0.01$) compared to ICU patients (Table 1).

There was no significant correlation between the workplace of patients and outcomes of COVID-19 (Figure-1).

Clinical characteristics and outcome

Correlation with mortality

Higher systolic blood pressure level and lower oxygen saturation on admission were associated with higher mortality ($P = 0.039$ and $P < 0.001$, respectively) (Table 1).

In patients with dyspnea, as the initial symptom of COVID-19, the mortality was higher ($P = 0.026$, OR: 4.10) (Table 2).

Table 2
The comparison of mortality and type of respiratory support in HCP regarding initial symptom

Outcome							
Symptom		Without invasive mechanical ventilation	With mechanical ventilation	P	Discharge (%)	Death (%)	P
Dry cough	No	97.6%(122/125)	2.4%(3/125)	0.487	96.8% (121/125)	3.2% (4/125)	0.491
	Yes	96.9%(248/256)	3.1%(8/256)		96.1% (246/256)	3.9% (10/256)	
Sputum production	No	97.4%(332/341)	2.6%(9/341)	0.443	96.5% (329/341)	3.5% (12/341)	0.324
	Yes	95%(38/40)	5%(2/38)		95%(38/40)	5%(2/38)	
Dyspnea	No	99%(189/191)	1%(2/191)	0.003 OR=4.7	98.4% (188/191)	1.6% (3/191)	0.026 OR=4.10
	Yes	95.3%(181/190)	4.7%(9/190)		94.2% (179/190)	5.8% (11/190	
Hemoptysis	No	97.1%(364/375)	2.9%(11/375)	0.838	96.3% (361/375)	3.7% (14/375)	0.798
	Yes	100%(6/6)	0.0		100%(6/6)	0.0	
Fever	No	98.4%(62/63)	1.6%(1/63)	0.432	96.8%(61/63)	3.2%(2/63)	0.584
	Yes	96.9%(308/318)	3.1%(10/318)		96.2% (306/318)	3.8% (12/318)	
Chills	No	97.7%(126/129)	2.3%(3/129)	0.456	96.1% (124/129)	3.9% (5/129)	0.543
	Yes	96.8%(244/252)	3.2%(8/252)		96.4% (243/252)	3.6% (9/252)	
Headache	No	95.7%(221/231)	4.3%(10/231)	0.031 OR=0.148	94.8% (219/231)	5.2% (12/231)	0.005 OR=0.24
	Yes	99.3%(149/150)	0.7%(1/150)		98.7% (148/150)	1.3% (2/150)	
Myalgia and fatigue	No	96.4%(106/110)	3.6%(4/110)	0.397	94.5% (104/110)	5.5% (6/110)	0.188
	Yes	97.4%(264/271)	2.6%(7/271)		97% (263/271)	3%(8/271)	
Weakness and fatigue	No	97.3%(362/372)	2.7%(10/372)	0.234	96.2% (358/372)	3.8% (14/372)	0.711
	Yes	88.9%(8/9)	11.1%(1/9)		100%(9/9)	0.0	
Anosmia	No	96.7%(326/337)	3.3%(11/337)	0.254	95.8% (323/337)	4.2% (14/337)	0.174
	Yes	100%(44/44)	0.0		100%(44/44)	0.0	
Hyposmia	No	96.9%(346/357)	3.1%(11/357)	0.484	96.1% (343/357)	3.9% (14/357)	0.396
	Yes	100%(24/24)	0.0		100%(24/24)	0.0	
Loss of sense of smell	No	96.5%(274/284)	3.5%(10/284)	0.184	95.4% (271/284)	4.6% (13/284)	0.109
	Yes	99%(96/97)	1%(1/97)		99%(96/97)	1%(1/97)	
Diarrhea	No	96.6%(285/295)	3.4%(10/295)	0.248	95.3% (281/295)	4.7% (14/295)	0.026 OR=0.953
	Yes	98.8%(85/86)	1.2%(1/86)		100%(86/86)	0.0	
Vomiting	No	97.1%(364/375)	2.9%(11/375)	0.838	96.3% (361/375)	3.7% (14/375)	0.798
	Yes	100%(6/6)	0.0		100%(6/6)	0.0	

However, headache and diarrhea as initial presentations of the disease were associated with lower mortality ($P = 0.005$, OR: 0.24 and $P = 0.026$, OR: 0.953, respectively) (Table 2).

Correlation with the need to MV

Higher respiratory rate and lower level of oxygen saturation on admission were correlated with the need for MV (*P* = 0.043 and *P* < 0.001, respectively) (Table 1).

Also, dyspnea on admission was associated with more need for MV (*P* = 0.003, OR: 4.7) (Table 2).

However, the presence of headache reduced the need for MV (*P* = 0.031, OR: 0.148) (Table 2).

Underlying conditions and outcome

Correlation with mortality

Concerning underlying conditions, hypertension (HTN), diabetes mellitus (DM), and current smoking have a significant correlation with mortality (*P* = 0.028, OR: 3.88; *P* = 0.005, OR: 6.48; and *P* = 0.024, OR: 12.07, respectively) (Table 3).

Table 3
The relationship of underlying disease of HCP with outcomes of Covid-19

Outcome					
Underlying disease		**Mechanical ventilation (%)**	**P**	**Death (%)**	**P**
Hypertension	No	2.4%/(8/330)	0.171	2.7%(9/330)	0.028
	Yes	5.9%(3/51)		9.8%(5/51)	OR=3.88
Diabetes mellitus	No	2.0%(7/347)	0.011	2.6%(9/347)	0.005
	Yes	11.8%(4/34)	OR=6.47	14.7%(5/34)	OR=6.48
Cardiovascular disease	No	2.7%(10/366)	0.361	3.6%(13/366)	0.436
	Yes	6.7%(1/15)		6.7%(1/15)	
COPD*	No	2.7%(10/374)	0.187	3.5%(13/374)	0.232
	Yes	14.3%(1/7)		14.3%(1/7)	
Chronic liver disease	No	2.9%(11/378)	0.916	3.7%(14/378)	0.893
	Yes	0.0		0.0	
Chronic kidney disease	No	2.9%(11/377)	0.889	3.4%(13/377)	0.140
	Yes	0.0		25.0%(1/4)	
Asthma	No	2.9%(11/378)	0.916	3.7%(14/378)	0.893
	Yes	0.0		0.0	
Multiple sclerosis	No	2.9%(11/380)	0.971	3.7%(14/380)	0.963
	Yes	0.0		0.0	
Hypothyroidism	No	3.0%(11/371)	0.581	3.8%(14/371)	0.531
	Yes	0.0		0.0	
Current smoking	No	2.4%(9/374)	0.111	3.2%(12/374)	0.024
	Yes	28.6%(2/7)		28.6%(2/7)	OR=12.07
*COPD-chronic obstructive pulmonary disease					

Correlation with the need to MV

DM as an underlying disease was associated with more need for MV (*P* = 0.011, OR: 6.47) (Table 3).

PPE and outcome

The use of PPE (as a combination of N95 face mask, gloves, gown, and eye shield) was associated with less mortality due to the coronavirus disease in HCWs (*P* = 0.023) (Table 4).

Table 4
The comparison of mortality regarding kind of PPE in HCP

Outcome	Discharge		death		P
	Count	Percent	Count	Percent	
Without any PPE	57	90.5	6	9.5	0.102
Only surgical mask	49	98.0	1	2.0	
Without any PPE	57	90.5	6	9.5	0.626
Only gloves	13	92.9	1	7.1	
Without any PPE	57	90.5	6	9.5	0.159
Surgical mask and gloves	57	96.6	2	3.4	
Without any PPE	57	90.5	6	9.5	0.179
Surgical mask,gown, gloves	70	95.9	3	4.1	
Without any PPE	57	90.5	6	9.5	0.023
N95 face mask, gloves, gown, eye shield	85	98.8	1	1.2	

In this study, the history of using different medications did not have a significant effect on the outcome.

Although patients were treated with oseltamivir, lopinavir/ritonavir, ribavirin, hydroxychloroquine, and levofloxacin according to the protocol, due to lack of information about the time of starting and duration of the treatment, we could not evaluate their effect on the outcomes.

Laboratory findings and outcome

Correlation with mortality

The mean and median of white blood cell count (WBC), neutrophil count, serum creatinine (Cr), lactate dehydrogenase (LDH), erythrocyte sedimentation rate (ESR), aspartate aminotransferase (AST), magnesium (Mg), and prothrombin time (PT) were statistically higher in the dead group ($P = 0.027$, $P < 0.001$, $P = 0.004$, $P = 0.001$, $P = 0.002$, $P = 0.02$, $P = 0.037$, and $P = 0.001$, respectively). Also, the mean and median counts of lymphocytes, absolute lymphocyte count, and serum albumin level were significantly lower in HCWs who were dead ($P < 0.001$, $P = 0.003$, and $P = 0.018$) (Appendix 1).

Correlation with the need to MV

The mean and median of WBC, neutrophil count, Cr, LDH, ESR, AST, alkaline phosphatase (ALP), and PT were higher in patients with MV ($P = 0.023$, $P < 0.001$, $P = 0.007$, $P < 0.001$, $P = 0.020$, $P = 0.037$, $P = 0.043$, and $P = 0.032$, respectively).

However, the mean and median of lymphocyte count, absolute lymphocyte count, calcium, and albumin were lower in mechanically ventilated patients ($P < 0.001$, $P < 0.001$, $P = 0.022$, and $P = 0.002$, respectively) (Appendix 2).

Imaging data and outcome

Multifocal ground glass opacities, peripheral ground glass opacities, and peribronchovascular involvement were associated with more need for MV and more death ($P = 0.001$, $P = 0.001$; $P = 0.022$, $P = 0.001$; and $P = 0.002$, $P = 0.001$, respectively (Table 5).

Table 5
The comparison of mortality and respiratory support status regarding the findings of lung HRCT

Outcome					
HRCT findings	No/Yes	Death	P	With MV*	P
Consolidation	No	3.4%(8/235)	0.722	3%(7/235)	0.892
	Yes	4.1%(6/146)		2.7%(4/146)	
Bilateral ground-glass opacities	No	2.8%(8/283)	0.135	2.1%(6/283)	0.129
	Yes	6.1%(6/98)		5.1%(5/98)	
Multifocal ground glass opacities	No	2.6%(9/347)	<0.001	1.7%(6/347)	<0.001
	Yes	14.7%(5/34)		14.7%(5/34)	
Unilateral ground-glass opacities	No	4%(14/350)	0.257	3.1%(11/350)	0.317
	Yes	0.0		0.0	
Peripheral ground-glass opacities	No	2.9%(10/349)	0.006	2.3%(8/349)	0.022
	Yes	12.5%(4/32)		9.4%(3/32)	
Peribronchovascular involvement	No	2.8%(10/359)	<0.001	2.2%(8/359)	0.002
	Yes	18.2%(4/22)		13.6%(3/22)	

*MV-mechanical ventilation

CT pattern of COVID-19 pneumonia includes: 33(0- Pattern no involvement .1- bronchopneumonia (Discrete lesion with a peribronchial distribution, CT signs with GGO or consolidation, or tree-in-bud sign or nodular opacity, Lung lobar involvement assessed by total CT score ≤of 5 .2- organizing pneumonia (Multifocal lesions with a peripheral distribution predominantly in the middle to lower lung zones, CT signs with GGO or consolidation, and/or interlobular septal thickening, Lung lobar involvement assessed by total CT score ≤6).3- progressive organizing pneumonia (Multiple lesions with a peripheral distribution predominantly in the middle to lower lung zones, CT signs with consolidation or GGO or mixed GGO and consolidation, and/or interlobular septal thickening, Lung lobar involvement assessed by total CT score more than 6 and < 10).4-diffuse alveolar damage(Lesions with extensive distribution diffusely in the entire lungs, CT signs with consolidation mixed with or without GGO, and/or air bronchograms, Lung lobar involvement assessed by total CT score more than or equal to 10) (33)

Multivariate analysis

The multivariate analysis using logistic regression between individual variables and blood groups, showed that the variables of age (OR = 1.12, 95% CI OR: 1.02–1.23, *P* = 0.014) and DM (OR = 10.73, 95% CI OR: 1.91–60.3, *P* = 0.007), and blood group B (OR = 19.2, 95% CI OR: 1.8–199.984, *P* = 0.013) in comparison with blood group O increase the risk of mortality and, similarly, the variables of blood group B (OR = 18.7, 95% CI OR: 1.5–229.15, *P* = 0.022), age (OR = 1.1, 95% CI OR: 1–1.2, *P* = 0.05), and DM (OR = 11.4, 95% CI OR: 1.7–78.5, *P* = 0.013) increase the risk of the need for MV. The sex variable remains as a predictor in the final logistic regression model but was not statistically significant.

Among clinical parameters, and based on the findings of HRCT, the presence of peribronchovascular involvement (OR = 1.1, 95% CI OR = 1.02–1.2, *P* = 0.019) and dyspnea (OR = 1.05, 95%CI OR = 1.01–1.09, *P* = 0.013) increase the risk of mortality, but the presence of diarrhea is not associated with the risk of mortality (OR = 0.95, 95%CI OR = 0.91–0.99, *P* = 0.018).

Also, dyspnea (OR = 1.04, 95% CI OR = 1–1.07, *P* = 0.037) and multifocal ground glass opacities (OR = 1.07, 95%CI OR = 1–1.14, *P* = 0.044) increase the risk of need for MV.

Among laboratory parameters, neutrophil count (OR = 1.09, 95% CI OR = 1.04–1.14, *P* < 0.001), alkaline phosphatase (OR = 1, 95% CI OR = 1.001–1.002, *P* = 0.001), and PT (OR = 1.027, 95% CI OR = 1.008–1.046, *P* = 0.005) increase the risk of mortality, but a higher level of absolute lymphocyte count (OR = 0.9995, 95% CI OR = 0.9993–0.9997, *P* < 0.001) decreases the mortality risk.

Based on the multivariate analysis of laboratory parameters, only alkaline phosphatase was observed to be the predictor of MV (OR = 1.0024, 95% CI OR = 1.0004–1.0044, *P* = 0.165).

Among systolic blood pressure, diastolic blood pressure, body temperature, respiratory rate, and oxygen saturation on admission, only O_2 saturation was found to be a mortality predictor (OR = 0.5312, 95% CI OR = 0.3955–0.7135, *P* < 0.001), and its higher levels decrease the mortality risk.

Also, only O_2 saturation was found to be the MV predictor (OR = 0.716, 95% CI OR = 0.579–0.884, *P* = 0.002).

We used the receiver operating characteristic curve (ROC) for significant parameters in multivariate analysis (Figure 2-3).

The cutoff predicted for mortality according to the optimal sensitivity and specificity method was 8400 for neutrophils (sensitivity = 83.3%, specificity = 92.9%), 176.50 for ALP (sensitivity = 83.3%, specificity = 71.4%), 13.50 for PT (sensitivity = 83.3%, specificity = 71.4%), and 600 for LDH (sensitivity = 66.7%, specificity = 85.7%) (Figure 2).

As shown in Figure 3, the cutoff of 90% for O_2 saturation on admission (sensitivity = 91.9%, specificity = 88.9%) and 1004 for absolute lymphocyte count (sensitivity = 81.8%, specificity = 66.6%) were estimated as predictors of mortality.

Discussion

The sudden onset and widespread of the COVID-19 disease challenged all capacities of health care systems in the affected areas and caused many changes in daily life and health systems all over the world, including Iran (1, 7). It has also resulted in a lot of work and increased psychological stress and mortality of medical staff as frontline soldiers (7).

This study aimed at evaluating the clinical, laboratory, and radiological manifestations of COVID-19 and the relationship between these presentations and the consequences of the disease and related risk factors in HCWs in Iran who reported the COVID-19 disease.

In our study, the prevalence of COVID-19 in HCWs was in total 5.62%, which is less than another study that showed 8%. Also, in the case of symptomatic patients, our study showed that the prevalence of COVID-19 in HCWs reached 72.98%, which is higher than another study that had shown 19% (6).

These differences may be due to the limitations in performing nasopharyngeal RT-PCR and HRCT of the lungs as the diagnostic test at that time, which was done only in severe symptomatic cases and not as a screening in all HCWs.

A total of 5.29% of females and 6.2% of males were infected with COVID-19, which is in line with other studies that showed more involvement in the male gender (7, 11). The mortality rate of infected HCWs in our study was 3.68%, but another two different meta-analyses reported that 0.5% and 1% of the infected HCWs died due to complications of the disease (6, 12).

The higher mortality in this study may be due to less access to diagnostic, protective, and treatment facilities and limitations of the ICU bed at that time.

In terms of gender, the mortality in infected females and males was 1.3% and 7.4%, which is a statistically significant difference like that found in other studies (7, 11, 13).

Justification of higher incidence of COVID-19 and its mortality in men is unclear, but less hand hygiene, more tobacco use, the higher level of ACE-2, disease denial, delay in disease follow-up, and less use of PPE may be some of the factors (7).

Also, old age (more than 60 years) was significantly correlated with a higher incidence of invasive ventilation and mortality like that shown in other studies (7, 14).

It may be due to lack of access and adequate use of PPE at that time or higher incidence of co-morbid diseases such as HTN, DM, and cardiovascular disease in the old population (7, 14). As seen in Table 1, invasive MV is more used in ICU compared to the COVID-19 general ward for the management of patients. Also, the mortality of patients in ICU is lower than that in the general ward, which can be due to better management of patients in ICU and less admission of critically ill patients to ICU due to bed restrictions.

This study shows that the presence of higher respiratory rate (RR), lower O_2 saturation, and blood group B are significantly correlated with invasive MV and mortality, and higher systolic pressure on admission is associated with higher death (Table 1).

We could not find any statistically significant correlation between body mass index (BMI), job categories of HCWs, workplace of HCWs, diastolic blood pressure, body temperature, and Rhesus factor with MV and death as outcomes of coronavirus infection (Table 1). These results are in agreement with another study that shows no correlation between them (11). However, some studies reported that general practitioners have higher mortality among doctors (7, 13) because they spend prolonged periods of time with COVID-19 patients, have more shift timing, and get more exposure to higher distress, which put them in the high-risk group (13).

In the case of the underlying disease, this investigation shows that history of DM is correlated with higher MV and death, but HTN and current smoking have a significant correlation only with mortality (Table 2). These results are in line with another study that shows the presence of HTN and DM as underlying diseases increases the risk of adverse COVID-19 outcomes (14).

The current investigation demonstrated that the use of PPE (a combination of N95 face mask, gloves, gown, and eye shield) was associated with less mortality in HCWs, but constant exposure to COVID-19 increases the risk and severity of infection in HCWs (13), while another study showed that the risk of exposure to COVID-19 at work is negligible. For optimal risk reduction in HCWs, more preventive care is recommended (14).

Concerning clinical signs, our research shows that only dyspnea, headache, and diarrhea on admission had a significant correlation with outcomes (Table 4). Patients with dyspnea are more likely to need MV ($P = 0.003$, OR = 4.7) and also suffer more mortality ($P = 0.026$, OR = 4.10) compared to patients without dyspnea. This finding is in line with results of other studies that showed that dyspnea is more associated with death (14–16).

Also, a longer interval between the onset of symptoms and the time of hospitalization is seen as one of the major causes of death (17).

This study showed that in patients with headache the need for MV and mortality rate were significantly lower ($P = 0.031$, OR = 0.148 and $P = 0.005$, OR = 0.24, respectively). This finding may be justified by the use of non steroidal anti-inflammatory drugs (NSAIDs) to relieve headaches, which may lead to a reduction in inflammation in other organs, including the lungs (16). However, it has not been confirmed by other studies (18). It may also be due to the faster referral of patients with severe headaches than patients without headaches to medical centers. This result is in line with other research works that showed the presence of headache is an independent predictor of lower risk of mortality in COVID-19 hospitalized patients (19, 20). Also, headache as an early symptom of COVID-19 indicates a short time interval from the onset of the disease to the clinical course (18). Another study showed no significant correlation between headache and severity of COVID-19 disease (21).

Based on the findings of this study, diarrhea as a presenting symptom of COVID-19 did not have any correlation with MV, but significantly correlated with lower mortality ($P = 0.026$, OR = 0.953). The mechanism by which diarrhea improves the prognosis of COVID-19 is likely to correct volume overload and improve lung congestion, which is commonly seen in severe COVID-19 disease, and probably correct hypermagnesemia (which is associated with higher mortality), as found in our study. This finding is in contrast to another study that found that the presence of diarrhea as a presenting feature of the disease is associated with severe features and probably poor outcomes (22–24). Also, a meta-analysis mentioned that the mortality rate in COVID-19 patients with gastrointestinal symptoms was the same as overall death (25).

With regard to the correlation between outcomes of COVID-19 and laboratory parameters, our research shows that the higher level of WBC, neutrophil count, serum creation, LDH, ESR, AST, and PT is significantly correlated with higher MV and death, but a higher magnesium level is correlated with higher death and higher ALP with a higher need of MV only. Also, lower levels of lymphocyte and absolute lymphocyte counts and serum albumin levels are associated with higher MV and mortality and lower calcium with MV only (Appendixes 1 and 2). The results of our study are in agreement with other research works (26–31). However, in this study, the role of platelet, ALT, and C-Reactive Protein (CRP) was not found to be statistically significant, and D-dimer, ferritin, and IL6 were not measured. This was reported to be the case with ALP in other research works (31). According to this study, the higher level of AST as against a normal ALT level may be attributed to a source other than the liver, such as muscles or heart. Also, higher ALP may be secondary to vitamin-D deficiency. Vitamin D has an antimicrobial and anti-inflammatory effect, so it has been recommended for the treatment of COVID-19 (32).

With regard to the correlation between imaging data and outcomes, as can be seen in Table 5, multifocal ground-glass opacities, peripheral ground-glass opacities, and peribronchovascular involvement were associated with more need for MV and death. The imaging findings of the present study are in agreement with other studies that revealed CT patterns 3 and 4 of lung involvement correlate well with the COVID-19 clinical severity and outcome (33, 34).

After adjustment of all significant variables by use of appropriate multivariate analysis, our study showed that blood group B, age, DM, dyspnea, neutrophilia, higher ALP, prolonged PT, lower O_2 saturation, and peribronchovascular involvement in HRCT of the lungs predict higher mortality and diarrhea as presenting symptoms, and higher lymphocyte and absolute lymphocyte counts predict lower mortality.

Also, the presence of blood group B, old age, DM, dyspnea, lower O_2 saturation, higher ALP, and multifocal ground glass opacity in HRCT of the lungs predict the need for MV.

Ultimately, this research estimated the cutoff for the potent predictors of mortality: O_2 saturation less than 90% with sensitivity = 91.9% and specificity = 88.9%, absolute lymphocyte count less than 1004/mL (sensitivity = 81.8% and specificity = 66.6%), neutrophil count more than 8400/mL (sensitivity = 83.3%, specificity = 92.9%), and LDH more than 600 (sensitivity = 66.7%, specificity = 85.7%).

The results of multivariate analysis in the present study are in agreement with another study (29). However, the cut-off and the sensitivity and specificity for the predictors of mortality predicted in this research are not mentioned in any other study.

Limitations

Our work has several limitations. First, we could not examine all health workers, including severely symptomatic staff, with RT-PCR at that time. Second, some necessary tests, such as cytokine levels, were not available in the patient's record. Finally, there was no report of involvement of the lungs on CT scan as a severity score in the file. To protect the medical staff from the COVID-19 pandemic and similar outbreaks, it is recommended that the underlying status of health care personnel, including demographic information, underlying diseases, medications, and blood groups, should be registered in health systems so HCWs at higher risk may be identified more quickly.

Conclusion

We concluded that the optimum use of PPE and screens by all HCWs, as well as close attention to the highly sensitive predictors of poor outcomes such as O_2 saturation less than 90% and absolute lymphocyte count less than 1004, more timely care, and adequate availability of beds in ICUs can reduce morbidity as well as mortality among HCWs.

Abbreviations

HCWs: health care workers

DM: diabetes mellitus

SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

RT-PCR: reverse-transcriptase–polymerase chain reaction

HRCT: high-resolution computed tomography

PPE: personal protective equipment

MV: mechanical ventilation

HTN: hypertension

WBC: white blood cell count

Cr: serum creatinine

LDH: lactate dehydrogenase

ESR: erythrocyte sedimentation rate

AST: aspartate aminotransferase

Mg: magnesium

PT: prothrombin time

ALP: alkaline phosphatase

CRP: C-reactive protein

ICU: Intensive care unit

Declarations

Ethics approval and consent to participate:

This study was approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1399.027).

Consent for publication:

Written informed consent was obtained from all participants initially.

Availability of data and materials:

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Competing interests:

The authors certify that no funding has been received for the conduct of this study and/or preparation of this manuscript and no conflicts of interest exist.

Funding:

No funding to declare.

Authors' contributions:

AM, AHM, LA, and MK designed the work. EK, LA, and SE analyzed and interpreted the patient data. LA, AHM, MRT, MK, SMR, AP, PA, NA, AF-M, MS, AFH, MHV, SAAF, AJ, AT, CG, IS, HAB, HH, AH, AMJ, SR, MH and BN-N collected the data. AM and LA were major contributors in writing the manuscript. AM, LA, and SE did critical revision of the article. All authors read and approved the final manuscript.

AM and LA designed the work and have drafted the work and substantively revised it.

AM, AHM, LA, and MK have drafted the work and substantively revised it. **AM, LA, EK, and SE** performed data collection, acquisition, analyzed the patient data and wrote the manuscript. **LA, AHM, MRT, MK, SMR, AP, PA, NA, AF-M, MS, AFH, MHV, SAAF, AJ, AT, CG, IS, HAB, HH, AH, AMJ, SR, MH and BN-N** had major contribution in Data collection and have drafted the work. **LA, and EK:** analyzed and interpreted the patient data. All authors read and approved the final manuscript.

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Appendix

Appendices 1 and 2 are not available with this version.

Figures

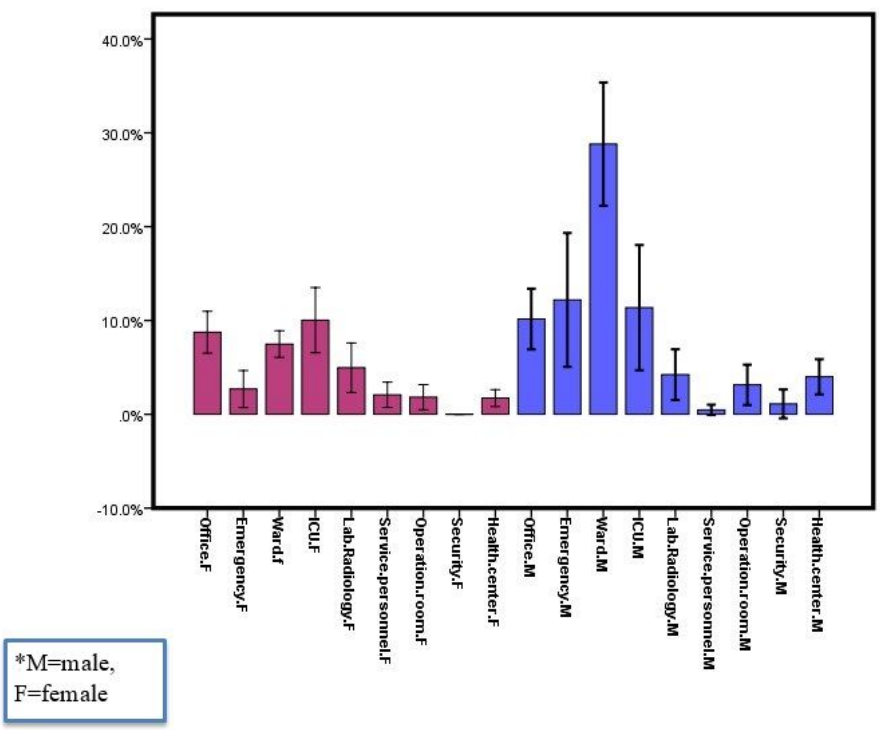

Figure 1

Correlation between the workplace of patients and outcomes of COVID-19

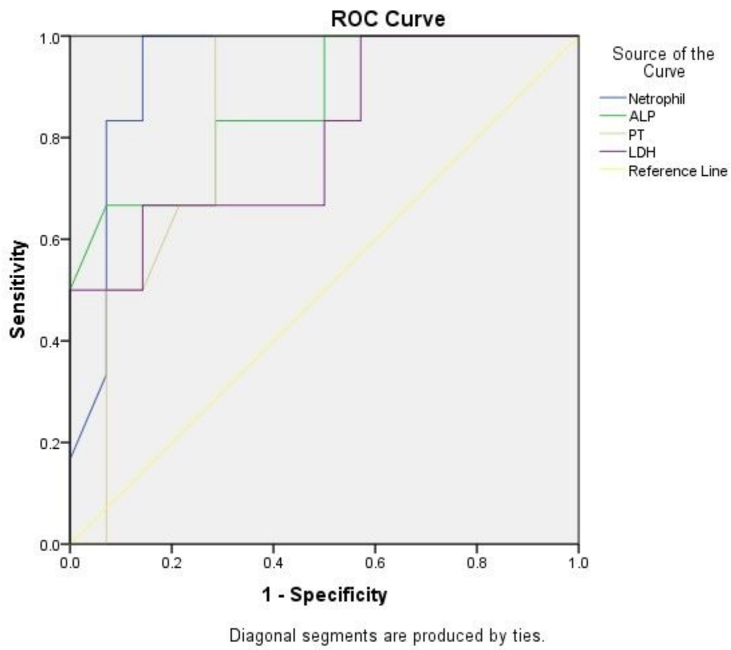

Figure 2

Sensitivity and specificity of Neutrophil, ALP, PT and LDH. ALP: Alkaline phosphatase PT: Prothrombin Time LDH: Lactate dehydrogenase

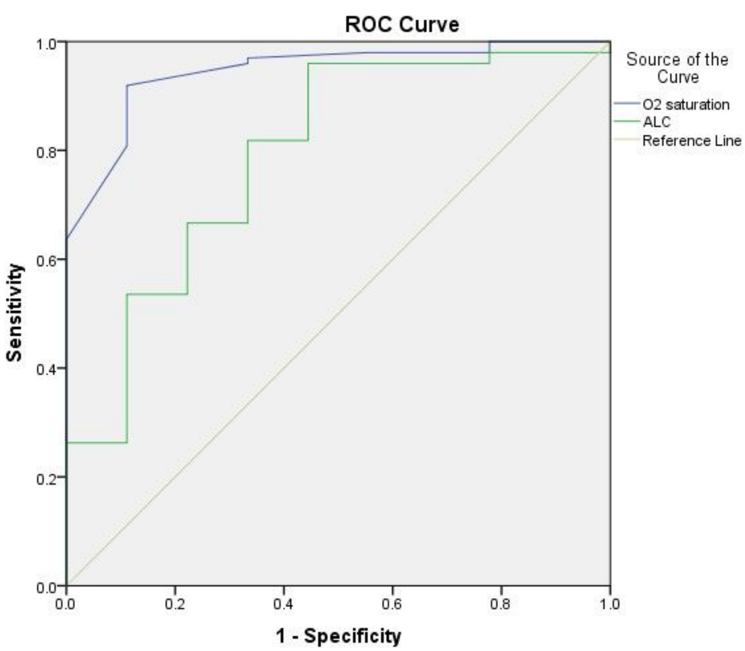

Figure 3

Sensitivity and specificity of O2 saturation and ALC. ALC: absolute lymphocyte count