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Comparative Study Of The Epidemiological, Clinical, And Biological Profile Between Diabetic And Non-Diabetic Patients With Covid-19 And Factors Associated With Mortality: A Moroccan Study

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Abstract

Diabetes has emerged as a significant comorbidity that affects the prognosis of patients with Coronavirus Disease 2019 (COVID-19). Understanding the differential impact of diabetes on the clinical course of COVID-19 is crucial for improving patient management and outcomes. This study aimed to explore and compare the epidemiological, clinical, and biological profiles of patients with and without diabetes with COVID-19 in Morocco and to identify the factors associated with mortality among the study population. This study included patients diagnosed with COVID-19 through RT-PCR and/or thoracic CT, who were admitted to Ibn Sina Hospital from August 2020 to August 2021 during the alpha and delta waves of SARS-CoV-2. Data were collected from the patients' medical records. Statistical analyses were conducted to highlight the significant differences and associated factors among the study population. A total of 268 patients were analyzed, with an average age of 60.7 years; 57.8% were men, and 44.4% were diabetic. Symptoms such as fever and dyspnea were prevalent in over 70% of cases. Statistical analysis revealed significant differences between patients with and without diabetes in terms of age, hypertension, cardiovascular diseases, severity of illness, and mortality rates. Key biological parameters, including hemoglobin, leukocyte, D-dimer, glycemia, urea, creatinine, troponin, and C-reactive protein (CRP) levels, also differed significantly between the two groups. Mortality was notably associated with factors such as age, glycemia, respiratory rate, and creatinine. Patients with diabetes exhibited a higher prevalence of hypertension (50.4% vs. 20.1%) and greater disease severity (55.5% vs. 42.3%), leading to an increased mortality rate (32.8% vs. 14.8%) compared with their non-diabetic counterparts. These findings underscore the distinct profiles of COVID-19 patients in Morocco based on diabetes status and highlight critical mortality risk factors within this population.

Keywords: COVID-19, Diabetes, Mortality, Morocco, Risk factors.

1 Introduction

Coronaviruses are a family of viruses, some of which can infect humans and often cause mild cold-like symptoms in humans. However, three deadly epidemics have occurred in the 21st century. These

involve emerging coronaviruses hosted by animals and suddenly transmitted to humans: SARS-CoV, MERS-CoV, and SARS-CoV-2, responsible for coronavirus disease 19 (COVID-19) [1].
Studies have shown that the pangolin coronavirus, a wild mammal consumed in China, exhibits a 91.02% similarity at the whole-genome sequence level with SARS-CoV-2. This indicates that pangolins may serve as intermediaries in the transmission of SARS-CoV-2 [2,3]. A recent investigation by a scientific team from the National Center for Scientific Research (CNRS), published in the journal Cell on Thursday, September 19, 2024, revealed the animal species most likely to have acted as intermediate hosts for SARS-CoV-2; thus, pangolins are definitively exonerated. Raccoon dogs or civets may be the animal species at the possible origin of the COVID-19 pandemic [4].
The COVID-19 pandemic has caused significant morbidity and mortality in over 200 countries and regions [5]. Diabetes has been identified as an independent factor associated with poor prognosis very quickly after the onset of the COVID-19 pandemic, and comorbidities, including diabetes, have emerged as associated with severe forms of COVID-19 [6–9].
Initial data from Wuhan, China, demonstrated a prevalence of diabetes ranging from 5% to 20% among patients admitted to the hospital for the treatment of COVID-19 [10]. In a study conducted by Grasselli et al., a diabetes prevalence of 17% was reported among patients admitted to intensive care units (ICUs) in Lombardy, Italy, for severe cases of SARS-CoV-2 infection [11]. A meta-analysis demonstrated that patients with diabetes have a significantly higher risk of Intensive Care Unit admission and mortality, with the risk of death being more than three times higher. The risk of ICU admission was more than twice that of the general population [12].
It is imperative to note that the prevalence of diabetes in patients admitted to intensive care units has been documented to be two- to threefold higher in individuals with less severe forms of the disease. Moreover, this elevated prevalence has been observed to be concomitant with a significantly increased mortality rate among those diagnosed with diabetes [12–16].
To the best of our knowledge, no prior research in Morocco has comprehensively examined the epidemiological, clinical, and biological characteristics of patients with and without diabetes diagnosed with COVID-19. The present study reinforces the findings of international studies that have addressed this theme during the peak of the pandemic, including the first and second waves of SARS-CoV-2, by evaluating and comparing the epidemiological, clinical, and biological profiles of patients with and non-diabetic patients suffering from COVID-19 and specifying the factors associated with mortality in the Moroccan population.

2. Materials and methods

2.1. Study design and setting

This retrospective, descriptive, comparative, and analytical study was conducted using the medical records of diabetic and non-diabetic patients with COVID-19 admitted and hospitalized in the AMU of Ibn Sina Hospital in Rabat from August 1, 2020, to August 1, 2021, which encompassed both waves of SARS-CoV-2. Notably, the AMU was designated as the first COVID-19 unit at Ibn Sina Hospital to receive patients who tested positive for SARS-CoV-2.

2.2. Study population

In terms of inclusion criteria, we considered all adult patients (>18 years old) with or without diabetes, admitted to the AMU of Ibn Sina Hospital in Rabat, for SARS-CoV-2 infection confirmed by RT-PCR and/or thoracic computed tomography (CT), utilizing the classification from the “COVID-19 Reporting and Data System» (CO-RADS). Data were collected from 767 patients diagnosed with COVID-19 and/or suspected of having COVID-19 between August 1, 2020, and August 1, 2021.
After excluding unusable patient files (such as those from pregnant women, patients under 18 years of age, and files with missing data), 268 files were included in this study. Disease severity was defined according to the WHO guidelines: patients with non-severe COVID-19 did not require supplemental oxygen and had pneumonia without signs of severe pneumonia. Patients with severe COVID-19 experience respiratory infection along with at least one of the following: severe respiratory distress, respiratory rate > 30 breaths per minute, or $SpO2 \leq 93\%$ on room air.

2.3. Data collection

A data sheet was created for each patient that detailed their socio-demographic characteristics (age, sex, origin), antecedents, and co-morbidities such as diabetes and high blood pressure (HBP), clinical characteristics including oxygen saturation, heart rate, biological and imaging findings, duration of hospital stay, therapeutic management, and the evolution of COVID-19.

2.3. Statistical analysis

Data entry was performed using the Sphinx Plus² software. Statistical processing and analysis were conducted using the Jamovi software version 2.4.2. First, descriptive statistics were generated to represent the variables tested in this study. Continuous variables are presented as means and standard deviations or medians and interquartile ranges, as appropriate. Categorical variables are presented as numbers and percentages.

Associations were assessed using the chi-square test for qualitative variables, the Mann-Whitney U test for quantitative variables with asymmetric distribution, and the Student's t-test for symmetric distributions to compare two independent groups. Simple and multiple logistic regression analyses were performed to evaluate the risk factors associated with mortality among COVID-19 patients with and without diabetes. Statistical significance was set at $p < 0.05$. Pearson and Spearman correlation analyses were conducted to evaluate the correlation between the main quantitative and qualitative parameters, respectively, using SPSS software.

3 Results

3.1. Demographic and clinical characteristics of the study population

Table 1 summarizes the demographic and clinical characteristics of the study population. This study involved 268 patients with positive COVID-19, divided into two groups: diabetic (N=119) and non-diabetic (N = 149) patients. The results showed that the mean age of patients was 60.7±15.7 years, with extremes of 18 and 100 years, and males accounted for 57.8% (n=155) of the total population. In addition, 97.4% (259) of the patients lived in urban areas. The mean time from symptom onset to hospital admission was 9 days ±7 days, and approximately 50% of the study population had a hospital stay of 9 days. More than half of our patients presented with fever, cough, fatigue, or dyspnea. Diabetes and HBP were the most frequent comorbidities in our COVID-19 patients, which represent 44.4% (n=119) and 33.6% (n=90), respectively, followed by heart disease (15.3%; n=41), lung disease (11.2%; n=30), and kidney failure (10.8%; n=29). The CT imaging report showed disproportionate lung involvement between patients, with a frequency of 35.8% (n=69) for CO-RADS class four (50-75% lung involvement) and 9.3% (n=18) for CO-RADS class five (lung involvement>75%). The recovery rate in our patients was 74.3% (n=199), while 37.3% (n=100) were admitted to the intensive care unit and 22.8% (n=61) died.

Table 1. Demographics and clinical characteristics of the study population.

Variables	Population N = 268
Sex *	
F	113(42.2)
M	155(57.8)
Age, (year)**	60.7±15.7 (18-100) #
Residence*(N=266)	
Urbain	259(97.4)
Rural	7(2 .6)
Exposure to patients*	123(46.9)
Yes	27(10.3)
No	96(36.6)
Duration from onset of symptoms to hospital admission(days)**	9.49±7.14(1-60) #
Presence of Signs and Symptoms*	
Fever	178(78.8)
Cough	130(61)

Fatigue	150(56)
Myalgia	88(38.9)
Dyspnea	154(72.3)
Headache	39(39.4)
Anosmia	34(34.3)
Agueusie	26(26.3)
Anorexia	29(10.8)
Diarrhea	24(51.1)
Oxygen saturation**	84.8±12.2(34 -100) #
Comorbidities* : Yes	
Diabetes	119(44.4)
HBP	90(33.6)
Cardiovascular disease	41(15.3)
Chronic kidney disease	29(10.8)
Pulmonary disease	30(11.2)
AVC	4(1.5)
Cancer/tumor	2(0.7)
No history of disease	49(18.3)
others	65(24.3)
Smoking status: *(N=235)	
Nonsmoker	191(81.3)
Smoker	44(18.7)
Duration of hospitalization (days)***	9[5 ;13]
PCR Analysis* :	179(67.3)
Positive	163(61.3)
Negative	16(6)
CT or scanner*	232(86.57)
<25%	54(28)
25 – 50%	52(26.9)
50-75%	69(35.8)
>75%	18(9.3)
Evolution and complication*	
Recovery	199(74.3)
Transfer to intensive care	100(37.3)
Death	61(22.8)

*Data are expressed as n (percentage); ** mean and standard deviation; # min-max; ***median and IQ.

3.2. Sociodemographic and clinical factors associated with COVID-19 patients among patients with and without diabetes

Statistical analysis revealed significant differences in age frequencies between patients with and without diabetes. Both groups of patients presented several comorbidities, of which hypertension was the most frequent comorbidity in diabetic patients at 50.4% (n=60) versus 20.1% (n=30) in the non-diabetic group. Cardiovascular diseases were observed in 21.0% (n=25) of diabetics and 10.7% (n=16) of non-diabetics, with significant p-values of <0.001 and 0.020, respectively.

Fever, cough, asthenia, and dyspnea were the most frequent symptoms in both groups. The CT findings in favor of lung involvement were almost identical for both groups of patients, with a small increase in the class (50-75% lung involvement); the difference was not significant.

Progression was favorable in non-diabetic patients, with a cure rate of 83.2% versus 63.0% in diabetic patients, and the difference was significant among all patients. Both groups had the same probability of being transferred to the intensive care unit (ICU). However, this difference was not statistically significant. There was also a significantly higher rate of severity between COVID-19 patients with and without diabetes (55.5% vs. 42.3%, p=0.032). Regarding the death rate, we noted a statistically significant

difference between patients with COVID-19 and diabetes (32.8 %; n = 39) and COVID-19 non-diabetic patients (14.8 %; n = 22). The results are summarized in Table 2.

Table 2. Sociodemographic and clinical factors associated with COVID-19 in patients with and without diabetes.

Variables	No Diabetes (%) (n=149)	Diabetes (%) (n=119)	P value
Gender			
Male	93(62.4)	62(52.1)	0.089
Female	56(37.6)	57(47.9)	
Age* (Year)			
<60	78(52.3)	35(29.9)	
≥60	71(47.7)	82(70.1)	<0.001
Residence*			
Urban	144(97.3)	115(97.5)	1.000
Rural	4(2.7)	3(2.5)	
Presence of Other comorbidities			
HBP	30(20.1)	60(50.4)	<0.001
Cardiovascular disease	16(10.7)	25(21.0)	0.020
Chronic pulmonary disease	21(14.1)	9(7.6)	0.092
Chronic kidney disease	18(12.1)	11(9.2)	0.458
Presence of Signs and Symptoms*			
Fever	103(79.8)	75(77.3)	0.646
Cough	77(62.1)	53(59.6)	0.707
Asthenia	87(58.4)	63(52.9)	0.372
Myalgia	55(42.6)	33(34.0)	0.189
Dyspnea	92(74.2)	62(69.7)	0.466
Headache	22(36.1)	17(44.7)	0.390
Ct or(scanner)*			
<25%	29(27.9)	25(28.1)	
25-50%	28(26.9)	24(27.0)	0.691
50-75%	35(33.7)	34(38.2)	
>75%	12(11.5)	6(6.7)	
Complication & evolution			
Recovery			<0.001
Yes	124(83.2)	75(63.0)	
No	25(16.8)	44(37.0)	
ICU			0.509
Yes	53(35.6)	47(39.5)	
No	96(64.4)	72(60.5)	
Death			<0.001
Yes	22(14.8)	39(32.8)	
No	127(85.2)	80(67.2)	
Severity			
Yes	63(42.3)	66(55.5)	0.032
No	86(57.7)	53(44.5)	

*Missing data. The p-values reflect comparisons between diabetes and without-diabetes patients. P<0.05 is statistically significant.

3.3 Biological parameters associated with COVID-19 patients among patients with and without diabetes

Table 3 summarizes the results of the physical examination and laboratory parameters in the diabetic and non-diabetic groups of our study population. The systolic rate differed between the two patient groups. Hemoglobin levels were lower in patients with diabetes (p=0.005). Hyperleukocytosis and neutrophil counts were significantly (p=0.012, p=0.032) higher in the diabetic group. D-dimer levels were significantly (p=0.007) higher in the diabetic group. In the non-diabetic group, the mean blood glucose level was 1.36 ± 0.55, thus confirming the recent discovery of diabetic patients who had been infected with SARS-CoV-2. Mean glycemia, urea, creatinine, and alkaline reserve were significantly higher in diabetics, with p-values of <0.001, <0.001, 0.003, and 0.048, respectively.

Regarding the markers of inflammation, protein reactive C (CRP) was above the normal range; however, it was higher among the diabetic patients, and the difference was significant (p=0.033) between both groups. There was also a considerable difference (p <0.001) between the median troponin levels of patients with and without diabetes.

Table 3. Biological parameters associated with COVID-19 in patients with and without diabetes.

	N	Diabetic n=119	N	Non-diabetic n=149	Normal range	p-value
		Mean ±SD Median [25 ;75]*		Mean ±SD Median [25 ;75]*		
Clinical parameters						
Oxygen saturation %	100	84±12.9	138	85.4±11.6	95-100	0.385
breathing rate cpm	102	27.1±6.51	142	26.4±6.57	12-20	0.423
Diastolic mmHG	109	70.26±10.44	141	70.41±10.30	80-89	0.393
Systolic mmHG	109	130.4±20.10	141	120.8±10.92	120-139	0.037
Laboratory parameters						
Hemoglobin	106	11.9±2.53	136	12.8±2.23	11.5-15.5	0.005
Leukocyte $x10^3$ /µl	106	12.376±8.336	134	10.074±5.769	4.0-10.0	0.012
LYM$x10^3$ /µl	104	0.90[0.65;1.35]*	132	0.90[0.64;1.46]	1.0-4.0	0.711
NEUT $x10^3$/µl	106	9.87±5.89	134	8.3±5.9	1.5-7	0.032
D-dimer(ng/L)	94	1.73[0.97;3.82]*	127	1.20[0.6;3.15]	<0.5	0.007
Fibrinogen(g/l)	87	5.94±2.21	122	6.43±2.22	2.0-4.0	0.118
Glycemia (g/L)	117	2.83±1.32	148	1.36±0.55	0.7-1.10	<0.001

Urea(g/L)	118	0.52[0.32;0.94]*	149	0.38[0.27;0.60]	0.15-0.55	<0.001
Creatinin(mg/L)	115	10.6[7.80;17]*	149	8.30[7.50;11.2]	5.7-12.5	0.003
SGPT or ALT(UI/L)	79	28[18.5;45.5]*	116	34[19 ;64.3]	0-55	0.349
SGOT(UI/L)	96	35[24;60.5]*	133	40[25 ;64]	5-34	0.492
Alkaline reserve(mEq/l)	114	22±7.09	139	23.4±4.17	22-31	0.048
Sodium(mEq/l)	118	136±7.55	149	137±4.29	136-145	0.708
Chlore(mEq/l)	118	98.8±9.19	148	97.1±10.7	98-107	0.195
LDH(U/L)	68	480[374;650]*	104	451[340;603]	125-220	0.225
Total Protein(g/L)	116	63.9±9.53	146	65.9±7.70	64-83	0.065
Ferritin(ng/ml)	102	659[366;1214]*	132	736[425;1405]	21-274	0.295
Troponin HS(ng/ml)	70	0.026[0.008;0.185]*	98	0.008[0.003;0.031]	<0.05	<0.001
CRP(mg/l)	117	151±110	148	125±91.2	<5	0.033

lym: lymohocyte; neut: neutrophils; plt: platelet; pt: prothrombin time; aptt: activated partial thromboplastin time; alt: alanine aminotransferase; sgot: serum glutamic-oxaloacetic transaminase; ggt: gamma-glutamyl-transpeptidase; ldh: lactate dehydrogenase; bnp: brain natriumpeptide; troponin hs: troponin high sensitivity; crp: c- reactive protein *data expressed as median and iqr ; the p value<0.05 is significant.

3.4 Risk factors associated with death in COVID-19 patients in Morocco: univariate and multivariate logistic regression

Table 4 shows the univariate and multivariate regression results of factors associated with COVID-19 mortality in diabetic and non-diabetic patients. The results of the multivariate logistic regression model showed that age (OR=1.06, p<0.001), glycemia (OR=1.58, p=0.002), breathing rate (OR=1.06, p=0.040), and creatinine (OR=1.02, p=0.006) were significantly associated with death in COVID-19 patients. In other words, the analysis of risk factors associated with mortality among COVID-19 patients in Morocco using both univariate and multivariate logistic regression identified several clinical and biological variables significantly linked to fatal outcomes. Age emerged as an independent risk factor, with each additional year increasing the risk of death by approximately 6% (OR=1.06; P <0.001), confirming that older individuals are more vulnerable to SARS-CoV-2. Blood glucose levels were also strongly associated with mortality, with a 58–77% increase in risk, depending on the model. This highlights the harmful impact of hyperglycemia and diabetes on prognosis, likely due to impaired immune and inflammatory responses in these patients. An elevated respiratory rate was another significant predictor of mortality, reflecting worsening respiratory function in critically ill patients. Additionally, creatinine levels, indicative of kidney function, were significantly correlated with mortality, suggesting that renal impairment plays a key role in adverse outcomes. Although C-reactive protein (CRP) was significant in the univariate analysis, it lost its predictive power in the multivariate model, indicating that its effect may be mediated by other inflammatory or clinical factors. Finally, the presence of cardiac disease showed a trend toward increasing the risk of death (OR=1.986), although this did not reach statistical significance (p=0.062), which does not rule out its clinical relevance. Overall, these findings emphasize the importance of close monitoring of patients with hyperglycemia, renal dysfunction, respiratory distress, or advanced age to better target medical interventions and improve survival outcomes in these patients.

Table 4. Risk factors associated with death in COVID-19 patients in Morocco: univariate and multivariate logistic regression.

Variable	Death (N=61) (Univariate)			(Multivariate)		
	OR	IC	p-value	OR	IC	p-value
Age	1.062	(1.037-1.088)	<0.001	1.06	(1.033-1.089)	<0.001
Cardiac disease	1.986	(0.966-4.048)	0.062			
Glycemia	1.771	(1.403-2.237)	<0.001	1.58	(1.179-2.108)	0.002
Breathing rate	1.070	(1.021-1.121)	0.004	1.06	(1.003-1.122)	0.040
CRP	1.003	(1.000-1.006)	0.027	1.00	(0.999-1.005)	0.303
Creatinine	1.010	(1.001-1.019)	0.028	1.02	(1004-1.026)	0.006

3.5. Correlation analysis

Pearson's correlation analysis highlighted several significant relationships between clinical and biological parameters, particularly in patients with diabetes (Table 5). Age is positively correlated with respiratory rate (r=0.216,p <0.01r = 0.216, p < 0.01), white blood cells (r=0.235,p<0.01r = 0.235, p < 0.01), neutrophils (r=0.218,p<0.01r = 0.218, p < 0.01), and fasting blood glucose (r=0.219,p<0.01r = 0.219, p < 0.01), suggesting an increase in inflammatory and metabolic markers with age, a phenomenon particularly pronounced in diabetic patients.

Inflammatory markers, especially CRP, showed positive correlations with respiratory rate (r = 0.205, p < 0.01), fibrinogen (r = 0.476, p < 0.01), and D-dimers (r = 0.225, p < 0.01), indicating a link between inflammation and respiratory dysfunction as well as coagulation disorders, which are often exacerbated in diabetic patients. Similarly, LDH, a marker of cell lysis, was positively correlated with white blood cells (r = 0.483, p < 0.01) and ferritin (r = 0.446, p < 0.01), highlighting strong inflammatory and immune activation, particularly problematic in diabetics due to their increased susceptibility to infections.

Renal markers also showed notable associations. Urea is correlated with neutrophils (r = 0.218, p < 0.01), while creatinine has a strong negative correlation with hemoglobin (r = -0.519, p < 0.01), suggesting a link between renal insufficiency and anemia, a common complication in diabetic patients.

Finally, fasting blood glucose was positively correlated with potassium (r = 0.167, p < 0.05) and negatively correlated with lymphocytes (r = -0.178, p < 0.05), which may reflect impaired glucose metabolism and weakened immune response in patients with diabetes. These findings underscore the complex interrelations between age, diabetes, inflammation, metabolic dysfunction, and immune response, highlighting the severity factors in COVID-19 patients.

Table 5. Pearson correlation between the main studied quantitative parameters.

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

	AGE	CAR_FRQ	RES_FRQ	GCS	HEM	W-GLO	PNN	LYMPH	MON	PNE	PNB	PLA	TP	TCA	FIB	D_DIM	CRP	SOD	POT	CHL	GLY	UREE	CREAT	ASAT	ALAT	PAL	GGT	PT	RA	LDH	FER	TRO
AGE	1																															
CAR_FRQ	-0.032	1																														
RES_FRQ	.216**	.204**	1																													
GCS	-.153*	0.044	-0.048	1																												
HEM	-0.136	-0.06	0.104	0.045	1																											
W-GLO	.235**	0.093	0.095	-.164*	-0.029	1																										
PNN	.218**	0.107	0.109	-.165*	0.034	.813**	1																									
LYMPH	-0.051	-0.023	-0.111	0.029	-0.01	0.124	-0.05	1																								
MON	0.119	0.002	-0.055	-0.088	0.019	.497**	.536**	.179*	1																							
PNE	-0.083	-0.034	-0.093	0.057	0.059	0.05	0.005	.213**	.225**	1																						
PNB	0.066	0.054	-0.024	-0.124	0.076	.334**	.383**	.183*	.472**	.362**	1																					
PLA	-0.015	-0.131	0.085	-0.147	.157*	.160*	.218**	0.017	.207**	.250**	.209**	1																				
TP	-0.122	0.02	0.012	.185*	0.133	-.238**	-.237**	-0.099	-.158*	-0.003	-.175*	0.071	1																			
TCA	0.105	-.151*	0.038	-0.075	-.287**	0.114	0.083	.153*	0.065	0.122	0.132	-0.121	-.433**	1																		
FIB	0.003	.220**	0.139	0.009	-0.017	.183*	.184*	-0.012	-0.006	0.016	0.036	.169*	.165*	0.029	1																	
D_DIM	0.008	0.042	0.071	0.025	-0.1	0.048	0.061	-0.088	0.096	0.029	0.114	-0.072	0.036	0	-0.103	1																
CRP	0.094	.146*	.205**	0.007	-0.092	.183*	.252**	-0.074	-0.011	-0.102	0.089	-0.042	-0.066	.225**	.476**	-0.001	1															
SOD	-0.06	-0.126	0.059	-.176*	.154*	0.083	0.088	0.045	.188*	-0.057	0.053	0.032	.157*	-0.105	-0.094	-0.105	-0.062	1														
POT	0.091	0.025	-0.021	-.290**	-0.055	.195**	.205**	-0.061	-0.011	0.05	0.076	.247**	-0.139	0.08	0.092	-0.027	0.053	-.203**	1													
CHL	0.018	-0.112	-0.032	-.177*	0.085	0.048	0.06	0.052	.200**	-0.036	-0.024	0.03	0.028	0.022	-0.034	-0.037	-0.072	.615**	-0.055	1											
GLY	.219**	-.144*	0.083	-0.117	-0.081	0.106	0.131	-.178*	-0.083	-.209**	-0.076	0.031	-0.026	0.11	-0.031	-0.025	0.131	-0.008	.167*	0.056	1										
UREE	.157*	0.008	-0.005	-0.062	-.467**	.253**	.218**	-0.057	0.092	-0.026	0.004	-0.06	-.181*	.292**	-0.141	0.094	-0.035	0.037	.183**	0.005	.196**	1									
CREAT	-0.016	-0.031	-0.105	-.171*	-.519**	0.099	0.08	-0.097	0.084	-0.014	0.003	-0.138	-0.076	.266**	-0.065	.298**	0.057	-.134*	.219**	-.175**	0.032	.762**	1								
ASAT	0.048	-0.005	0.146	0.058	0.129	.316**	.182*	0.041	0.019	0.011	0.047	-0.087	-.295**	.190*	-0.036	-0.024	-0.027	-0.045	0.053	-0.023	-0.045	-0.005	-0.07	1							
ALAT	-0.029	-0.067	0.155	0.04	0.116	.326**	.189*	0.015	0.035	-0.009	0.03	-0.064	-.286**	0.122	-0.057	-0.017	-0.047	0.017	0.06	0.036	-0.038	-0.015	-0.106	.914**	1						
PAL	.234**	0.105	.196*	0.038	-0.07	0.044	0.101	-0.025	0.123	0.031	0.124	0.041	-.263**	0.123	-.177*	.497**	-0.017	-0.039	0	0.05	0.034	0.041	-0.018	.324**	.385**	1					
GGT	0.025	0.011	0.161	0.072	.163*	-0.092	-0.048	-0.045	0.028	0.013	-0.006	-0.008	-0.079	-0.12	-0.117	0.111	-0.076	0.034	-0.017	0.075	0.001	-0.084	-.183*	.286**	.371**	.682**	1				
PT	-.182**	0.082	-0.051	.148*	.431**	-0.054	-0.085	0.065	-0.043	.154*	0.063	0.113	.156*	-0.062	0.095	-0.053	-0.025	-0.108	.178**	-.168*	-0.083	0.037	-0.066	0.046	0.011	-0.143	-0.033	1			
RA	-0.046	-0.067	0.066	0.132	.272**	-0.023	-0.068	-0.03	0.093	0.043	0.077	.145*	.156*	-.267**	-0.045	-0.074	-0.085	0.113	-.217**	-.163*	-.251**	-.148*	-.296**	-0.011	0.014	-0.076	0.013	-0.133	1		
LDH	0.098	0.032	.227**	-0.181	.180*	.483**	.375**	-0.012	0.041	0.102	.228*	-0.039	-.311**	0.141	-0.017	0.059	.167*	0.059	.206*	-0.013	0.056	.331**	0.045	.665**	.564**	0.098	0.072	0.152	-0.086	1	
FER	0.037	-0.051	0.088	-0.148	0.005	.483**	0.117	-0.139	0.003	-0.15	-0.054	-0.084	-0.071	-0.047	0.052	0.003	0.051	0.093	0.02	0.002	0.052	0.013	0.114	.395**	.403**	-0.009	0.056	-0.127	0.13	.446**	1
TRO	0.024	0.118	-0.067	0.047	0.085	.201*	.219*	0.055	.311**	0.021	0.112	-0.042	-0.106	-0.005	-0.028	-0.009	0.086	0.02	-0.028	0.019	-0.035	0.004	0.022	0.007	-0.018	0.027	-0.002	0.069	-0.074	.238*	0.016	1

Spearman correlation analysis highlighted several significant relationships between clinical and biological variables and outcomes in COVID-19 patients (Table 6). First, hypertension (HTA) was positively correlated with age ($r = .182$, $p < 0.01$) and obesity ($r = .172$, $p < 0.01$). Similarly, diabetes showed a strong correlation with HTA ($r = .345$, $p < 0.01$) and cardiopathy ($r = .233$, $p < 0.01$), whereas its treatment was strongly negatively correlated with the presence of diabetes ($r = -.945$, $p < 0.01$), which was expected.

Fever was significantly negatively correlated with cardiopathy ($r = -.327$, $p < 0.01$) and pulmonary diseases ($r = -.155$, $p < 0.05$), whereas asthenia was inversely related to COVID-19 vaccination ($r = -.219$, $p < 0.01$). Conversely, myalgia was positively correlated with the presence of psychiatric conditions ($r = .155$, $p < 0.05$) and negatively associated with cardiopathy ($r = -.143$, $p < 0.05$). Anosmia and ageusia, on the other hand, showed a strong correlation between them ($r = .857$, $p < 0.01$) and were also negatively associated with hypertension ($r = -.133$, $p < 0.05$ and $r = -.132$, $p < 0.05$, respectively).

In terms of treatment, oxygen therapy was positively correlated with diabetes ($r = .198$, $p < 0.01$) and negatively associated with psychological management ($r = -.193$, $p < 0.01$). The use of hydroxychloroquine was positively associated with vaccination ($r = .208$, $p < 0.01$) but negatively correlated with the presence of psychiatric conditions ($r = -.136$, $p < 0.05$). Additionally, the use of vitamin C, zinc, and corticosteroids showed a strong interrelation ($r = .488$, $p < 0.01$; $r = .467$, $p < 0.01$; and $r = .300$, $p < 0.01$, respectively).

Finally, regarding patient outcomes, recovery was negatively correlated with HTA ($r = -.157$, $p < 0.05$) and diabetes ($r = -.194$, $p < 0.01$), whereas death was significantly associated with cardiopathy ($r = .227$, $p < 0.01$), pulmonary diseases ($r = -.167$, $p < 0.05$), and diabetes ($r = .207$, $p < 0.01$). Transfer to the intensive care unit was positively correlated with obesity ($r = .149$, $p < 0.05$) and HTA ($r = .136$, $p < 0.05$). Notably, there was a strong negative correlation between death and recovery ($r = -.887$, $p < 0.01$), confirming the relevance of the analyses conducted.

Table 6. Spearman's correlation between the main studied qualitative parameters.

	Sex	Origin	Vacc	HTA	Pul_path	Ins	Hrt-path	Psy_path	Obes	Alco	Diab	Tob_act	Dia_trt	Asthenia	Myalgia	Fever	Cough	Dyspnea	Kidneys	Anosmia	Ageusia	Ano	Diar	Vom	Oxy-ther	Hydro	Azith	Vit_c	Vit_d	Zinc	Cort	Antic	Healing	Comp	Death
Sex	1																																		
Origin	-0.004	1																																	
Vacc	0.068	-.156*	1																																
HTA	.182**	-0.015	-0.02	1																															
Pul_path	-0.049	-0.068	-0.058	-0.013	1																														
Ins	-0.018	0.105	-0.016	0.127	-0.044	1																													
Hrt-path	0.102	0.098	-0.013	.168*	-0.002	0.035	1																												
Psy_path	-0.013	-0.027	-0.079	-0.04	-0.057	-0.051	-0.003	1																											
Obes	.165*	-0.034	.132*	.172**	-0.072	-0.065	-0.097	-0.028	1																										
Alco	-0.084	-0.017	-0.013	0.035	-0.036	-0.032	0.067	-0.014	-0.018	1																									
Diab	0.106	-0.049	0.09	.345**	-0.112	-0.032	.233**	-0.067	0.03	0.015	1																								
Tob_act	.225**	-0.072	0.14	0.118	-0.126	0.066	-0.121	-0.091	0.091	-0.083	0.101	1																							
Dia_trt	-0.082	0.025	-0.075	-.282**	.131*	0.024	-.195**	0.064	0.013	-0.018	-.945**	-0.119	1																						
Asthenia	0.032	0.056	-.219**	0.092	-0.113	0.073	-0.128	0.072	0.025	-0.106	-0.06	0.123	0.038	1																					
Myalgia	-0.026	-0.012	-0.028	-0.076	-0.118	0.042	-.143*	.155*	-0.027	-0.064	-0.091	-0.026	0.094	.283**	1																				
Fever	0.005	0.015	-0.031	-.129*	-.155*	0.116	-.327**	-0.024	-0.02	-0.035	-0.101	-0.014	0.069	.244**	.295**	1																			
Cough	-0.004	-0.019	0.048	-0.022	0	0.012	-.132*	-0.025	-0.041	0.097	-0.014	0.024	-0.029	0.101	0.07	.263**	1																		
Dyspnea	-0.037	-.154*	0.102	-0.032	0.092	-.163*	0.036	-0.051	0.117	0.081	-0.058	-0.009	0.105	-0.115	-0.03	-0.08	0.084	1																	
Kidneys	-0.047	-0.077	-0.046	-0.095	-0.019	0.01	-0.103	.182**	-0.016	-0.04	-0.053	0.054	0.042	-0.029	0.066	-0.032	-0.057	-.181**	1																
Anosmia	-0.076	-0.075	-.192**	-.133*	-0.084	-0.102	-0.123	.190**	-0.012	-0.039	-0.108	-.148*	0.073	.196**	.163*	0.081	-0.01	-0.108	0.09	1															
Ageusia	-0.008	-0.069	-.209**	-.132*	-0.069	-.132*	-0.104	0.119	-0.003	-0.036	-0.122	-0.1	0.087	.187**	0.124	.132*	0.039	-0.107	0.046	.857**	1													
Ano	0.03	-0.067	0.06	0.099	-0.026	-0.044	-0.002	0.033	-0.072	-0.036	0.02	0.062	-0.031	.283**	0.022	0.041	0.079	0.092	-0.092	-0.011	-0.03	1												
Diar	0.018	-0.052	-.141*	0.061	-0.066	0.001	0.04	-0.045	-0.057	-0.028	0.096	-0.033	-0.105	-0.021	-0.103	.141*	0.089	0.069	-0.086	-0.036	-0.022	0.076	1											
Vom	-0.023	.200**	-.160*	-0.069	-0.034	0.034	0.015	0.053	-0.062	-0.03	0.022	-.196**	-0.044	0.049	-0.031	0.005	-0.048	-.135*	0.023	-0.011	-0.038	-0.03	0.117	1										
Oxy-ther	-0.059	-0.087	0.099	0.065	-0.028	-0.101	0.086	-.193**	0.074	0.039	.198**	0.021	-.160*	-0.035	0.038	-0.011	-0.022	.349**	-0.093	-0.036	-0.022	.159*	0.036	-.212**	1									
Hydro	-0.066	-.165*	.208**	0.044	0.126	-0.127	-0.028	-.136*	-0.024	0.072	0.012	-0.029	-0.022	-0.039	.137*	.134*	.175**	.199**	-.148*	-0.025	-0.012	0.126	0.031	-0.011	.207**	1								
Azith	0.027	0.032	-0.004	0.029	0.002	-.167*	-0.022	0.029	0.034	0.018	-0.03	-0.017	0.034	0.12	0.079	0.126	0.045	0.124	0.018	0.08	0.074	0.074	-0.03	-0.103	0.056	.254**	1							
Vit_c	-0.027	0.039	-0.078	-0.007	0.091	-.175**	0.022	0.036	0.042	0.022	-0.038	-0.057	0.042	.189**	0.12	0.092	0.075	0.032	-0.005	0.1	0.034	0.032	0.001	0.008	0.013	.231**	.488**	1						
Vit_d	-0.017	0.002	-0.085	.131*	-0.031	-0.055	0.062	-0.019	0.021	0.068	0.12	-0.008	-.149*	0.118	0.091	-0.031	0.015	-0.007	-0.019	-0.037	-0.076	-0.03	-0.05	0.037	0.045	0.116	.165*	.288**	1					
Zinc	-0.048	0.041	-0.088	0.006	0.095	-.162*	0.03	0.037	0.044	0.023	-0.021	-0.065	0.064	.203**	0.128	0.076	0.053	0.052	0.004	0.051	-0.015	0.038	0.006	0.014	0.059	.208**	.467**	.959**	.304**	1				
Cort	0.031	-0.09	0.001	0.007	0.081	-0.107	0.08	-0.025	0.073	0.039	0.087	-0.111	-0.072	0.079	0.088	0.048	0.042	0.053	-0.065	-0.006	0.01	0.119	0.032	-0.001	.262**	.140*	.196**	.300**	.135*	.281**	1			
Antic	-0.027	-0.083	-0.078	0.077	-0.027	-0.046	0.071	-0.099	0.042	0.022	0.042	0.012	-0.038	-0.05	0.035	0.007	-0.004	0.111	-0.113	0.044	0.034	0.032	0.072	-0.06	.237**	.190**	0.061	0.12	-0.045	0.111	0.13	1		
Healing	-0.107	0.046	0.123	-.157*	.166*	-0.024	-.231**	0.089	0.059	0.056	-.194**	0.018	.190**	0.073	0.107	0.073	.138*	-0.057	0.092	0.024	0.024	-0.07	-.145*	0.059	-.158*	0.103	-0.003	0.087	0.069	0.116	-0.06	-0	1	
Comp	0.072	-0.069	.137*	.136*	0.032	0.031	0.033	0.008	.149*	0.025	0.015	-0.084	-0.014	-0.105	-0.121	-0.035	-0.061	0.101	-0.052	-0.017	-0.059	0.032	0.063	-0.12	.211**	0.039	0.048	0.02	0.034	-0.01	0.097	0.047	-.322**	1
Death	0.054	-0.02	-0.102	0.124	-.167*	0.025	.227**	-0.08	-0.044	-0.05	.207**	-0.018	-.213**	-0.042	-.138*	-0.112	-.154*	0.013	-0.05	-0.038	-0.044	0.115	.146*	-0.06	0.121	-0.081	-0.016	-0.117	-0.034	-.150*	0.017	-0.03	-.887**	.209**	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

4. Discussion

In this study, the mean age of patients diagnosed as positive for SARS-CoV-2 was 60.7 years, with a standard deviation of 15.7 years. This result is higher than the mean age reported in a Chinese study (56 years) [17], and the American study (57.5 years) [18]. This result was lower than that reported in numerous other studies, including the French study (72 years) [19], and the Belgium study (67 years) [20], however, it was similar to that observed in the CORONADO, French study (60,2 years) [21]. The preponderance of males in this study may be attributed to the protective effects of the X chromosome and sex hormones, which play a pivotal role in innate and adaptive immunity [22]. Additionally, fever, cough, dyspnea, fatigue, and diarrhea were the most prevalent symptoms among patients with COVID-

19, aligning with previous studies in Morocco and worldwide [18,23–25]. Similarly, diabetes and HBP were the more frequent comorbidities in this study, with 44.4 and 33.6%, respectively. This differs from the findings of American and Chinese studies, which reported a higher frequency of HBP than diabetes (50.1% vs 25.2%) and (16.9% vs 8.2%), respectively in COVID-19 patients [26–28]. This finding may be explained by the increasing prevalence of HBP in this population compared to the general Moroccan population [29–31]. A comparison of the physical parameters of diabetic and non-diabetic patients revealed that those with diabetes had higher systolic pressure and a greater prevalence of cardiovascular disease than those without diabetes. This finding follows the results reported by Al Salameh et al. [19]. Our findings demonstrated that even patients without a history of diabetes were prone to developing a novo form of diabetes following their SARS-CoV-2 infection. Additionally, their mean blood glucose levels were observed to be lower in comparison to diabetic patients with SARS-CoV-2 infection. A study carried out in Italy showed the presence of new-onset hyperglycemia with insulin resistance and beta-cell overstimulation in patients with COVID-19 without a history of diabetes. They also reported that infection with SARS-CoV-2 can induce an inflammatory state similar to that seen in type 2 diabetes [32]. The data suggest that the mechanism underlying the development of new-onset diabetes is primarily dependent on the ability of SARS-CoV-2 to use the angiotensin-converting enzyme 2 (ACE2) receptor to invade and translocate into human cells, particularly the pancreatic islets, the result in the destruction of islet mass and a significant decline in insulin production [33]. This phenomenon may be linked to the elevation in blood sugar levels observed in diabetic patients and the onset of new-onset diabetes in non-diabetic individuals.

Analysis of the biological profile of the studied population showed that diabetic patients tended to be anemic, with a low rate of hemoglobin and increasing levels of polynuclear neutrophils, as well as markedly elevated levels of D-dimer and inflammatory markers (CRP and LDH), compared with those without diabetes (Table 3). Fox et al. [34] showed that patients with diabetes had higher peak inflammatory markers such as CRP. Moreover, numerous studies have documented the presence of chronic inflammation in patients with diabetes [35–37]. This correlation was of increasing significance in the context of the COVID-19 pandemic. Furthermore, the rate of troponin-hs was found to be increasing in 35 diabetic patients with COVID-19 in comparison with only 16 non-diabetic patients with other comorbidities, including HBP and cardiovascular disease. The study conducted by Codeanu et al. [38] demonstrated that an elevation in troponin was associated with advanced age and the presence of comorbid conditions, such as pre-existing HBP and diabetes.

The findings of this study indicate that non-diabetic patients demonstrated a more favorable progression against SARS-CoV-2 infection compared to diabetic patients. Targher et al. revealed that patients with diabetes may exhibit elevated ACE2 expression, which could facilitate viral uptake and elevate the risk of severe illness [39]. Pazoki et al. [40] showed that diabetes was a significant factor in the increased severity of the disease. Additionally, previous studies have identified several factors that are associated with the severity of COVID-19, mainly the presence of co-morbidities such as diabetes, cardiovascular disease, and elevated blood pressure [27,41,42]. In addition, older age was significantly associated with mortality and a risk factor in the population-based study. Consistent with our findings, a previous study found that age was an independent risk factor for severe disease in SARS-CoV-2 infection, and contributed to a fatal outcome in hospitalized COVID-19 patients [24,28,43]. Indeed, Borzouei et al. [44] reported that age greater than 60 years was a risk factor for mortality in both non-diabetic and diabetic COVID-19 patients.

Furthermore, the results of the multivariate regression analysis indicated that glycemia, breathing rate, and elevated creatinine levels were significantly associated with mortality in both diabetic and non-diabetic patients with SARS-CoV-2 infection. Several studies conducted during the same period have identified hyperglycemia-induced changes in the immune system and increases in inflammatory factors as potential mechanisms for the observed increase in mortality [45–47]. Moreover, the study conducted by Pazoki et al. [40] revealed a positive correlation between creatinine levels and mortality in patients infected with SARS-CoV-2.

5. Conclusions

In this study, statistically and clinically significant differences in the biological, physical, and clinical parameters between patients with and without diabetes were identified. Following a comparative

analysis of these two groups (those with and without diabetes), we determined that diabetes was a significant comorbidity in Moroccan patients diagnosed with SARS-CoV-2. Furthermore, the mortality rate was higher in the diabetic population. This finding underscores the challenges confronting the diabetic population during and after the pandemic, prompting public health authorities to underscore the vulnerability of this demographic and emphasize the pressing need for enhanced care strategies for patients with diabetes.

The paucity of research on the impact of SARS-CoV-2 on patients with diabetes in Morocco has been addressed in the present study, which has enriched the database of Moroccan research on this theme. It also enables officials of the Moroccan Ministry of Health to maintain an overview of the epidemiological and biological profiles of the Moroccan population. However, health authorities must prioritize large-scale multicenter studies to better understand the metabolic disturbances caused by viral infections such as SARS-CoV-2 and to support exhaustive multidisciplinary research into the long-term repercussions of the pandemic on recovered individuals to better understand and overcome the current health obstacles.

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