Early Online

The European Research Journal 2025 Original Article

DOI: https://doi.org/10.18621/eurj.1599508 *Bioengineering*

Comparison of changes in blood group, hemogram and biochemical parameters in healthcare workers with and without COVID-19

Atakan Turan[1], Hamdi Öğüt[1], Hayri Bozkurt[2], Aylin Ayyıldız Varol[3]

[1]Department of Bioengineering, Faculty of Engineering and Natural Sciences, Bursa Technical University, Bursa, Türkiye; [2]Department of Family Medicine, Bursa Çekirge State Hospital, Bursa, Türkiye; [3]Department of Internal Medicine, Bursa Çekirge State Hospital, Bursa, Türkiye

ABSTRACT

Objectives: This study aimed to evaluate blood groups and some hematologic and biochemical parameters in healthcare workers with and without COVID-19.

Methods: The sample consisted of 1232 healthcare workers who consented to participate in the study after being informed about its purpose and methodology. The study's case group consisted of 704 individuals who got COVID-19, whereas the control group consisted of 528 individuals who didn't get the virus. A survey conducted online was used to gather data. The study was conducted with adherence to ethical norms.

Results: Participants in the case and control groups showed a significant difference in their vitamin D level variables, and those with low vitamin D levels were 1.9 times more likely to contract COVID-19 than those with normal levels. Blood glucose, lactate dehydrogenase (LDH), ferritin, troponin-I, D-dimer, C-reactive protein (CRP), anti- human immunodeficiency virüs (HIV), white blood cell, hemoglobulin, platelets, lymphocyte, and neutrophil averages were significantly different between the case and control groups when the biochemistry values of the participants were compared ($P<0.05$).

Conclusions: Vitamin D level, blood glucose, LDH, ferritin, troponin I, D-dimer, CRP, and anti-HIV among the significant biochemistry parameters in our study; leukocyte, hemoglobin, platelets, lymphocyte, and neutrophil levels among hemogram parameters are in parallel with the literature data in predicting the diagnosis of COVID-19. The use of these parameters in the clinic will contribute to the early detection of the diagnosis, early isolation of patients, and early initiation of the treatment process.

Keywords: Biochemistry, COVID-19, hemogram, blood group, healthcare worker

The World Health Organization (WHO) announced on December 31, 2019, that a disease of unknown origin with severe respiratory symptoms has emerged in Wuhan, Hubei province, China [1]. On January 7, 2020, it was discovered that a new type of coronavirus (2019-nCoV) that had never been discovered in humans was the cause of severe respiratory symptoms; this infection was dubbed "COVID-19" [2]. Members of the Coronaviridae family, coronaviruses (SARS-CoV, MERS-

Corresponding author: Atakan Turan, Pharmacist, PhD student, Phone: +90 224 300 32 32, E-mail: ecz.atakanturan@hotmail.com

How to cite this article: Turan A, Öğüt H, Bozkurt H, Ayyıldız Varol A. Comparison of changes in blood group, hemogram and biochemical parameters in healthcare workers with and without COVID-19. Eur Res J. 2025. doi: 10.18621/eurj.1599508

Received: December 11, 2024
Accepted: January 12, 2025
Published Online: February 18, 2025

CoV, and SARS-CoV-2) are enclosed viruses with a single-stranded, positively polarized, single-stranded RNA genome that is around 27-32 kb in size [3]. On December 1, 2019, the WHO declared a pandemic after the COVID-19 epidemic extended to 216 nations, infecting 12 million people. On March 11, 2020, the first case was seen in Turkey [4].

In order to stop and manage the spread of infection, our country and other countries have begun implementing a number of preventative measures in response to the COVID-19 pandemic. Curfews, travel restrictions, remote work, distance learning, flexible or rotating work schedules, social distancing regulations, and mask obligations are some of the measures that have had a significant impact on people and caused physical and mental health issues for survivors [4,5]. The people most impacted by this circumstance are healthcare professionals. On the front lines, healthcare workers—our most powerful force in the pandemic-have battled the risk of spreading the virus to their loved ones and themselves [6].

Finding indicators that may be utilized to forecast disease severity and risk is necessary because of the rapid transmission and possible fatality of SARS-CoV-2. Healthcare professionals may lessen transmission, use resources effectively during the pandemic, avoid needless hospitalizations, and lessen all associated effects by identifying patients at high risk of developing a serious or deadly disease [7]. Standard, quick, simple, and inexpensive blood tests that can help with COVID-19 diagnosis and prognosis include serum biochemistry and complete blood count studies [8]. COVID-19 cannot be diagnosed based only on laboratory results. Despite the fact that the final diagnosis of COVID-19 is made microbiologically, this approach aids in the diagnosis when combined with the patient's contact history, clinical findings, certain laboratory results, imaging techniques, and is useful for patient follow-up [9]. Examining blood types and some hematologic and biochemical characteristics in healthcare professionals with and without COVID-19 was the goal of this study.

METHODS

Purpose and Type of Study

This study aimed to evaluate blood groups and some hematologic and biochemical parameters in healthcare workers with and without COVID-19. It is a single-center, retrospective, and cross-sectional case-control study.

Population and Sample of the Study

The study population consisted of 2100 healthcare workers who worked in Bursa Çekirge State Hospital between 2020-2022 and continued to work between December 2022 and December 2023. The sample consisted of 1232 healthcare workers who agreed to participate in the study after being informed about the purpose, content, and method. The sample consists of two groups. The case group consists of 704 people who contracted COVID-19 and agreed to participate in the study, and the control group consists of 528 people who did not contract COVID-19 and agreed to participate.

Inclusion criteria

All medical staff members who consented to take part and who had the most recent COVID-19 blood group, biochemistry, and hemogram results in the hospital registration system between December 2022 and December 2023 at Bursa Çekirge State Hospital.

Exclusion Criteria

Participants with disabilities such as hearing, writing, or visual impairments that prevented them from participating in the study were excluded, as were those who did not want to complete the questionnaire, those who could not be contacted because they were on leave or reporting, and those who marked the questionnaire form as incomplete or multiple times.

Data Collection Tool

A questionnaire was used to gather data. Descriptive questions about the participants were asked in the first section of the questionnaire, and questions concerning blood types, biochemistry, and hemogram test findings were asked in the second.

Data Collection

The study's questionnaire was distributed to participants by message board, email, and WhatsApp. The online questionnaire was developed using "Google Forms." Before beginning to answer the questions, participants who fulfilled the sampling criteria and consented to participate in the study filled out the questionnaire. Completing the online data col-

Table 1. **Demographic characteristics of the participants in the case and control groups and comparison between groups**

		Case group (n=704)		Control group (n=528)		Statistical analysis and P value	Odds Ratio	95% Confidence Interval	
		n	%	n	%			Min.	Max.
Gender	Female (ref.)	439	62.4	289	54.7	χ^2=7.253[a] **P=0.007**	**1.370**	1.128	1.665
	Male	265	37.6	239	45.3				
Blood group	0 Rh + (ref.)	187	26.6	160	30.3	χ^2=4.866[a] P=0.676			
	0 Rh -	30	4.3	27	5.1		0.951	0.587	1.539
	A Rh +	279	39.6	200	37.9		0.725	0.402	1.306
	A Rh -	46	6.5	30	5.7		0.796	0.497	1.277
	B Rh +	95	13.5	67	12.7		0.643	0.301	1.374
	B Rh -	19	2.7	11	2.1		0.784	0.467	1.315
	AB Rh +	43	6.1	32	6.1		0.222	0.041	1.216
	AB Rh -	5	0.7	1	0.2		0.827	0.458	1.492
Vitamin D level	Low (ref.)	244	34.7	120	22.7	χ^2=26.709[b] **P<0.001**			
	Normal	359	51.0	341	64.6		**1.931**	1.551	2.405
	High	4	0.6	6	1.1		3.050	0.970	9.590
	No information available	97	13.8	61	11.6		1.279	0.928	1.762

[a]Pearson Chi-Square test, [b]Fisher Exact test

lection took an average of ten minutes. The correctness of the hemogram, biochemistry, and blood group findings was validated by the hospital registration system.

Ethical Aspects of the Study

The study's ethical aspects were accepted by the Bursa City Hospital Clinical Research Ethics Committee on March 17, 2021 (Decision No: KAEK/2021.05.02) before to its commencement. At every stage of the study, the Declaration of Helsinki was followed, and participants were informed using a "voluntary consent form" that the researchers had created.

Statistical Analysis

Data analysis was conducted using the SPSS 20.0 software. Data related to continuous variables were re-

Table 2. Comparison of biochemistry results of case and control group participants between groups

	Case group (n=704)	Control group (n=528)	Statistical analysis and P value
Fasting glucose (mg/dL)	108.44±37.405	83.87±8.062	t=14.835 **P=0.000**
Urea (mg/dL)	36.09±25.027	36.60±21.137	t=0.384 P=0.701
Creatinine (mg/dL)	1.02±**0**.699	1.01±**0**.553	t=0.058 P=0.954
ALT (IU/L)	23.95±36.827	24.90±36.536	t=0.451 P=0.652
AST (U/L)	28.15±32.550	25.91±24.879	t=1.314 P=0.189
LDH (U/I)	412.34±85.950	153.98±30.567	t=66.004 **P<0.001**
Ferritin (µg/L)	262.99±89.753	40.25±43.030	t=52.662 **P<0.001**
Troponin I (ng/L)	45.48±9.210	3.73±4.706	t=32.530 **P<0.001**
D-Dimer (mg/L)	0.82±1.064	0.31±0.159	t=10.968 **P<0.001**
CRP (mg/dL))	34.92± 46.297	4.94±8.377	t=14.699 **P<0.001**
Anti-HBs (mIU/mL)	362.23±422.659	401.11±449.683	t=1.555 P=0.120
Anti-HIV	0.13±0.098	0.12±0.072	t=2.037 **P<0.001**
Vitamin B12 (pg/mL)	345.75±60.774	344.03±32.963	t=0.201 P=0.841
Cholesterol (mg/dL)	204.18±44.573	201.73±43.359	t=0.967 P=0.334

Data are shown as mean±standard deviation. ALT=alanine aminotransferase, AST=aspartate aminotransferse, LDH=lactate dehydrogenase, CRP=C-reactive protein, Anti-HBs=hepatitis B surface antibody, HIV=human immunodeficiency virus
t=Independent samples t-test

ported as means in statistical analyses, whereas data related to categorical variables were expressed as numbers (n) and percentages (%). Qualitative and quantitative variables were compared using the chi-square and independent samples t-tests, respectively. An examination of logistic regression was conducted. The Hosmer-Lemeshow Test was used to assess model fit. The sample size was found to be suitable and there were no issues with multicollinearity or outliers when the assumptions were assessed before to the analysis. Odds Ratio (OR) and confidence interval (CI: Confidence Interval) were calculated using logistic regression analysis. The enter method was used in logistic regression. The significance level was accepted as $P<0.05$.

RESULTS

A significant difference was observed between the case and control groups according to the gender characteristics of the individuals ($P<0.05$). The case and control groups were found to be similar to one another when comparing the blood group characteristics of their individuals ($P>0.05$). Regarding the vitamin D level characteristics of the participants in the case and control groups, there was a significant difference between the groups ($P<0.05$) (Table 1).

The mean glucose levels of the individuals in the case and control groups showed a significant difference between the groups ($P<0.05$). In terms of mean lactate dehydrogenase (LDH) levels, there was a significant difference between the case and control groups ($P<0.05$). There was a significant difference in the mean ferritin levels between the case and control groups ($P<0.05$). Analysis of the case and control groups' mean troponin I levels revealed a significant difference ($P<0.05$). In terms of mean D-dimer levels, there was a significant difference between the case and control groups ($P<0.05$). In terms of mean C-reactive protein (CRP) levels, there was a significant difference between the case and control groups ($P<0.05$). Participants in the case and control groups had mean anti-human immunodeficiency virus (anti-HIV) values that differed significantly from one another ($P<0.05$). It was determined that there was no significant difference between the mean values of Urea, Creatinine, alanine aminotransferase (ALT), aspartate aminotransferase (AST), hepatitis B surface antibody (anti-HBs), vitamin B12, and cholesterol of the participants in the case and control groups ($P>0.05$) (Table 2).

There was a significant difference in the mean white blood cell (WBC) levels between the case and control groups ($P<0.05$). There was a significant difference ($P<0.05$) in the mean Hemoglobin levels between the case and control groups. Comparing the participants' mean Platelets values revealed a significant difference between the groups ($P<0.05$). The participants in the case and control groups had significantly different mean plateletcrit (PCT) ($P<0.05$). There was a significant difference between the case and control groups ($P<0.05$) when comparing the mean lymphocyte of the participants. A significant difference between the groups was discovered when the individuals' mean lymphocyte % was assessed ($P<0.05$). Participants in the case and control groups had mean neutrophils that differed significantly from one another ($P<0.05$). The averages of neutrophils % in the case and control groups differed significantly ($P<0.05$). The case and control groups' participants' mean values forred blood cell (RBC), red blood cell distrubition wide (PDW) %, RDW-standard deviation (SD)%, basophil count, basophil %, monocytes count, monocytes %, eosinophil count, and eosinophil % did not vary significantly ($P>0.05$) (Table 3).

DISCUSSION

It is crucial to guarantee good triage, suitable isolation, and effective utilization of potentially scarce testing resources during infectious disease epidemics. Using peripheral blood samples for hemogram and biochemistry analysis is an easy, quick, and affordable diagnostic procedure. Thus, the purpose of our study was to assess blood types as well as certain hematologic and biochemical characteristics in healthcare professionals who had and did not have COVID-19.

According to the blood types of the study's participants, A Rh+ was the most frequently encountered blood type in both the case and control groups, whereas AB Rh- was the least frequently encountered. Blood group A was the most prevalent blood group among healthy COVID-19 patients in the study conducted by Muniz-Diaz *et al*. [10]. There was no dis-

Table 3. Comparison of hemogram results of case and control group participants between groups

	Case group (n=704)	Control group (n=528)	Statistical analysis and P value
WBC ($\times10^9$/L)	10.67±7.853	5.91±1.068	t=13.830 **P<0.001**
RBC ($\times10^{12}$/L)	4.69±0.501	4.68±0.443	t=0.671 P=0.502
Hemoglobin (g/dL)	12.03±0.761	14.92±0.710	t=67.825 **P<0.001**
Platelets ($\times10^9$/L)	202.25±60.193	290.42±62.745	t=24.983 **P<0.001**
Platelets %	0.35±0.033	0.19±0.045	t=69.763 **P<0.001**
PDW %	16.70± 1.615	16.59±1.593	t=1.,214 P=0.225
RDW-SD %	41.97±4.079	41.71±4.015	t=1.083 P=0.279
Basophil ($\times10^9$/L)	0.03±0.056	0.04±0.072	t=0.786 P=0.432
Basophil %	0.57±0.576	0.63±0.914	t=1,486 P=0,138
Lymphcyte ($\times10^9$/L)	1.66±0.429	3.02±0.678	t=43.164 **P<0.001**
Lymphcyte %	24.93±6.449	45.44±10.176	t=43.164 **P<0.001**
Monocyte ($\times10^9$/L)	0.54±0.463	0.53±0.552	t=0.445 P=0.656
Monocyte %	7.31±4.860	7.19±5.291	t=0.392 P=0.695
Eosinophil ($\times10^9$/L)	0.17±0.167	0.16±0.148	t=1.232 P=0.218
Eosinophil %	2.30±1.974	2.25±.,986	t=0.429 P=0.668
Neutrophil ($\times10^9$/L)	8.74±3.000	4.21±1.248	t=32.553 **P<0.001**
Neutrophil %	92.50±12.226	60.06±10.126	t=49.540 **P<0.001**

Data are shown as mean±standard deviation. WBC=white blood cell, RBC=red blood cell, RDW=red blood cell distribution width. SD=standard deviation

t=Independent samples t-test

cernible variation in blood group variability across the groups [10]. In a research conducted in Bahrain, the ABO distribution was comparable between the control group and the Covid-19-infected group. The most prevalent blood group was O, which was followed by A and B. Our study's least represented blood type was AB [11]. O blood group individuals were significantly less likely to be infected with SARS-COV-2 than non-O participants, according to another study done in Iraq that analyzed 200 patients with detected SARS-CoV-2 infection, ABO blood group, and clinical data. On the other hand, people with blood group A were more likely to get infected [12]. There was no difference between the groups when Wu *et al*. [13] examined the impact of blood types on COVID-19 patients and healthy people. The blood types of COVID-19 positive and negative were examined in the study by Nalbant *et al*. [14]. that looked at the connection between COVID-19 disease and blood type. The same study found that the blood group had no effect on COVID-19. The results are similar to our study.

Vitamin D is an essential regulator of immunity. Vitamin D deficiency/insufficiency threatens public health and primarily affects individuals more prone to contracting COVID-19 [1]. In this study, a significant difference was found between the case and control group participants in terms of vitamin D levels. At the same time, those with low vitamin D levels had a 1.9 times higher risk of having COVID-19 compared to those with normal levels (OR=1.931; 95% CI=1.551-2.405; P<0.001).

Anti-insulin hormones such growth hormone, glucagon, cortisol, and catecholamines rise in response to stressful situations like disease, which also causes an increase in gluconeogenesis. Increases in interleukin-1, interleukin-6, and tumor necrosis factor-alpha during infection lead to the development of insulin resistance. Blood glucose levels rise as a result of these two processes. Tissues' capacity to use glucose declines with increasing insulin resistance [15]. In our study, the case group's blood glucose levels were significantly higher than those of the control group. Similar to our findings, Lymperaki *et al*. [16] discovered in their study that those with COVID-19 had significantly higher glucose levels. This study observed no significant difference between AST and ALT values. In the study of Thapa *et al*. [17] on biochemistry values in individuals with and without COVID-19, AST and ALT values were significantly higher in COVID-19 patients.

Adipose and liver cells create the acute-phase protein known as C-reactive protein (CRP), which is elevated in inflammatory and infectious conditions. A biochemical metric known as CRP rises in COVID-19 disease and all inflammatory conditions. Hussein *et al*.'s [18] investigation of patients with and without COVID-19 revealed a significant difference between the two groups, with CRP values being higher in the COVID-19 patients. In this investigation, the case group's CRP value was significantly greater than the control group's. In the study conducted by Rostam *et al*. [19] with COVID-19-positive and healthy individuals, the LDH values of COVID-19-positive individuals were significantly higher than those of the healthy group. In the study of Thapa *et al*. [17], LDH values were significantly higher in COVID-19 patients compared to the healthy group. Although the CRP values of COVID-19 patients were higher than those of healthy patients in the Rostam *et al*.'s [19] study, there was not a significant variation between the two groups [19]. Higher LDH, ferritin, and CRP levels were found in COVID-19 patients [20]. CRP appears to be an essential regulator of inflammatory processes rather than a marker like ferritin [21].

A cytoplasmic enzyme called lactate dehydrogenase (LDH) transforms lactic acid into pyruvic acid. The tiniest rise in serum signifies cell injury since intracellular LDH levels are 500 times greater than serum levels. Participants in the case group in our study had considerably higher LDH levels than those in the control group. Additionally, Hussein *et al*. [18] discovered that the LDH count was noticeably higher than that of the control group.

The severity of the COVID-19 infection is strongly correlated with higher D-DIMER levels. The case group in this study had a significantly greater D-DIMER value than the control group. D-dimer values were significantly higher in patients with COVID-19, according to a study by Hussein *et al*. that compared patients with and without the virus [18]. D-dimer levels were greater in COVID-19 patients in several studies [17, 19]. Ahmed *et al*. [22] found that unvaccinated COVID-19 patients had a significantly greater D-dimer level than healthy individuals. Ferritin levels were shown to be significantly higher in COVID-19 patients in the same study, which is comparable to ours [22].

Troponin I is the most specific marker of myocyte damage caused by myocardial ischemia in peripheral blood. In this study, the case group's troponin levels in COVID-19 patients were significantly higher than those in the control group. Tersalvi *et al*. [23] showed that troponin levels increased in COVID-19 infection and increased further as the severity of the disease increased.

Participants in the case group in our study had a significantly higher WBC level than those in the control group. Hussein *et al*.'s [18] study of patients with and without COVID-19 revealed a significant difference between the two groups, with WBC levels being greater in the COVID-19 patients. In 2020, Soraya *et al*. [24] published a meta-analysis study that looked at hemogram and biochemistry characteristics that can be used to diagnose COVID-19. In support of the diagnosis of COVID-19, the data showed a substantial drop in leukocyte ($P<0.001$), neutrophil ($P<0.01$), and platelet ($P<0.05$) levels [24]. Kiss *et al*. [25] found that WBC and D-DIMER levels increased and lymphocyte values decreased in COVID-19 patients in severe conditions and intensive care.

In this study, the hemoglobulin value was significantly lower in the case group than in the control group. Similar to our study, Ahmed *et al*. [22] found that the hemoglobulin value of unvaccinated COVID-19 patients was significantly lower than that of individuals in the healthy group.

Comparing the case group to the control group, we found that the case group individuals had significantly lower numbers and percentages of lymphocyte and platelets values. By inhibiting growth and inducing death after the virus infects bone marrow progenitor cells, we can demonstrate that the pathophysiological mechanism of reduced platelet synthesis from megakaryocytes is the reason for the decline in platelet levels in COVID-19 patients [26]. Additionally, Hussein *et al*. [18] discovered that the proportion of lymphocyte and platelets values values was considerably lower than that of the control group [18]. Ahmed *et al*.'s [22] study on COVID-19 patients revealed that, in comparison to the healthy group, lymphocyte values had drastically dropped. However, there was a little drop in the platelets value when compared to the healthy group [22].

According to our study, there was a substantial difference between the case group's and the control group's participants, with the case group's neutrophil count and percentage being greater. Hussein *et al*.'s [18] study, which included patients with and without COVID-19, found that there was a significant difference between the two groups and that the proportion of neutrophils was greater in the COVID-19 patients. Because they have lower autoimmunity and higher neutrophil counts, which indicate higher levels of inflammation, COVID-19 patients are more vulnerable to bacterial and fungal infections as the condition worsens [27]. The study by Wu *et al*. [28] showed that individuals with COVID-19 had significantly increased neutrophil counts, while lymphocyte and platelet levels decreased compared to those unaffected.

Important biochemistry parameters in our study include vitamin D level, blood glucose, LDH, ferritin, Troponin I, D-Dimer, CRP, and Anti-HIV; hemogram parameters such as leukocyte, hemoglobin, platelet, lymphocyte, and neutrophil levels are in line with the data from the literature in predicting the diagnosis of COVID-19. Early diagnostic detection, early patient isolation, and early treatment beginning are all facilitated by the use of these parameters in the clinic.

CONCLUSION

The findings of this study indicate a strong correlation between COVID-19 and both high and low levels of hematologic and biochemical markers. In order to diagnose COVID-19 utilizing blood and blood biochemistry tests, which act as biomarkers to predict infection, these factors are crucial. Our study's blood results proved to be a reliable indicator of COVID-19 infection. Therefore, the prognosis of the disease may be assessed using these values.

Ethical Statement

The study was approved by the Bursa City Hospital Clinical Research Ethics Committee (Decision no: KAEK/2021-5/2 and date: 17.03.2021) before to its commencement. At every stage of the study, the Declaration of Helsinki was followed, and participants were informed using a "voluntary consent form" that the researchers had created.

Authors' Contribution

Study Conception: AT, HÖ, AAV; Study Design: AT, HÖ, HB; Supervision: AT, HÖ, HB; Funding: AT,

HB, AAV; Materials: AT, HB, AAV; Data Collection and/or Processing: AT, HB, AAV; Statistical Analysis and/or Data Interpretation: AT, HÖ; Literature Review: AT, HB, AAV; Manuscript Preparation: AT, HÖ, HB, AAV; and Critical Review: AT, HÖ, HB, AAV.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The authors disclosed that they did not receive any grant during conduction or writing of this study.

Acknowledgment

We thank Çekirge State Hospital health workers for their time and dedication

REFERENCES

1. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395(10223):497-506. doi: 10.1016/S0140-6736(20)30183-5.
2. Lu R, Zhao X, Li J, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. Lancet. 2020;395(10224):565-574. doi: 10.1016/S0140-6736(20)30251-8.
3. Pyrc K, Dijkman R, Deng L, et al. Mosaic structure of human coronavirus NL63, one thousand years of evolution. J Mol Biol. 2006;364(5):964-973. doi: 10.1016/j.jmb.2006.09.074.
4. Budak F, Korkmaz Ş. [An Overall Evaluatıon for the Covıd-19 Pandemıc Process: The Case Of Turkey]. Sosyal Araştırmalar ve Yönetim Dergisi (SAYOD). 2020;(1):62-79. doi: 10.35375/sayod.738657. [Article in Turkish]
5. İnce F, Evcil FY. [The First Three Weeks of the Covid-19 in Turkey]. 2020 Mar ;11(2):236-41. doi: 10.22312/sdusbed.719168. [Article in Turkish]
6. Imran N, Zeshan M, Pervaiz Z. Mental health considerations for children & adolescents in COVID-19 Pandemic. Pak J Med Sci. 2020;36(COVID19-S4):S67-S72. doi: 10.12669/pjms.36.COVID19-S4.2759.
7. Li X, Liu C, Mao Z, et al. Predictive values of neutrophil-to-lymphocyte ratio on disease severity and mortality in COVID-19 patients: a systematic review and meta-analysis. Crit Care. 2020;24(1):647. doi: 10.1186/s13054-020-03374-8.
8. Yang M, Ng MH, Li CK. Thrombocytopenia in patients with severe acute respiratory syndrome (review). Hematology. 2005;10(2):101-105. doi: 10.1080/10245330400026170.
9. Guan WJ, Ni ZY, Hu Y, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. N Engl J Med. 2020;382(18):1708-1720. doi: 10.1056/NEJMoa2002032.
10. Muñiz-Diaz E, Llopis J, Parra R, et al. Relationship between the ABO blood group and COVID-19 susceptibility, severity and mortality in two cohorts of patients. Blood Transfus. 2021;19(1):54-63. doi: 10.2450/2020.0256-20.
11. Almadhi MA, Abdulrahman A, Alawadhi A, Rabaan AA, Atkin S, AlQahtani M. The effect of ABO blood group and antibody class on the risk of COVID-19 infection and severity of clinical outcomes. Sci Rep. 2021;11(1):5745. doi: 10.1038/s41598-021-84810-9.
12. Hussein AD, Bakr EA, Al-Jumaili MHA. Association between ABO blood groups and the risk of infection with SARS-CoV-2 in Iraq. J Int Med Res. 2022;50(11):3000605221133147. doi: 10.1177/03000605221133147.
13. Wu Y, Feng Z, Li P, Yu Q. Relationship between ABO blood group distribution and clinical characteristics in patients with COVID-19. Clin Chim Acta. 2020;509:220-223. doi: 10.1016/j.cca.2020.06.026.
14. Nalbant A, Aydın A, Yaylacı S, Kaya T, Wermeulen CL, Cinemre H. Association of ABO blood group and age with COVID-19 positive test. Rev Assoc Med Bras (1992). 2021;67Suppl 1:46-50. doi: 10.1590/1806-9282.67.Suppl1.20200703
15. Robinson LE, van Soeren MH. Insulin resistance and hyperglycemia in critical illness: role of insulin in glycemic control. AACN Clin Issues. 2004;15(1):45-62. doi: 10.1097/00044067-200401000-00004.
16. Lymperaki E, Kazeli K, Variti G, et al. Potential Role of Certain Biomarkers Such as Vitamin B12, ROS, Albumin, as Early Predictors for Prognosis of COVID-19 Outcomes. Medicines (Basel). 2022;9(6):36. doi: 10.3390/medicines9060036.
17. Thapa A, Malla R, Koirala R, et al. Comparison of Biochemical Parameters in COVID-19 and non-COVID-19 Individuals in Gandaki Province, Nepal. Fortune J Health Sci. 2023;6(3):246-252. doi: 10.26502/fjhs.122.
18. Hussein MM. Comparison between Alterations in some Hematological and Biochemical Parameters in COVID-19 and non-COVID-19 Patients Albaida, Libya. Sci J Faculty Sci-Sirte Univ. 2022;2(1):33-37. doi: 10.37375/sjfssu.v2i1.170.
19. Rostam SRK, Shekhany KAM, Smail HO. Comparative study of some biochemical parameters among of COVID-19 symptoms and non COVID-19 symptoms individuals. Biovalentia: Biol Res J. 2020;6(2):9-14. doi: 10.24233/biov.6.2.2020.180.
20. García LF. Immune Response, Inflammation, and the Clinical Spectrum of COVID-19. Front Immunol. 2020;11:1441. doi: 10.3389/fimmu.2020.01441.
21. Sproston NR, Ashworth JJ. Role of C-Reactive Protein at Sites of Inflammation and Infection. Front Immunol. 2018;9:754. doi: 10.3389/fimmu.2018.00754.
22. Ahmed HS, Nanakali NMQ, Ali KA. Comparison of Biochemical Parameters in Vaccinated and Non-vaccinated SARS-COV-2 Patients in Erbil-City. Cihan Univ-Erbil Sci J. 2024;8(1):46-57. doi: 10.24086/cuesj.v8n1y2024.pp46-57.
23. Tersalvi G, Vicenzi M, Calabretta D, Biasco L, Pedrazzini G, Winterton D. Elevated Troponin in Patients With Coronavirus Disease 2019: Possible Mechanisms. J Card Fail. 2020;26(6):470-475. doi: 10.1016/j.cardfail.2020.04.009.
24. Soraya GV, Ulhaq ZS. Crucial laboratory parameters in COVID-19 diagnosis and prognosis: An updated meta-analysis. Med Clin (Engl Ed). 2020;155(4):143-151. doi: 10.1016/j.med-

cle.2020.05.004.
25. Kiss S, Gede N, Hegyi P, et al. Early changes in laboratory parameters are predictors of mortality and ICU admission in patients with COVID-19: a systematic review and meta-analysis. Med Microbiol Immunol. 2021;210(1):33-47. doi: 10.1007/s00430-020-00696-w.
26. Yang AP, Liu JP, Tao WQ, Li HM. The diagnostic and predictive role of NLR, d-NLR and PLR in COVID-19 patients. Int Immunopharmacol. 2020;84:106504. doi: 10.1016/j.intimp.2020.106504.
27. Wang X, Liu W, Zhao J, et al. Clinical characteristics of 80 hospitalized frontline medical workers infected with COVID-19 in Wuhan, China. J Hosp Infect. 2020;105(3):399-403. doi: 10.1016/j.jhin.2020.04.019.
28. Wu C, Chen X, Cai Y, et al. Risk Factors Associated With Acute Respiratory Distress Syndrome and Death in Patients With Coronavirus Disease 2019 Pneumonia in Wuhan, China. JAMA Intern Med. 2020;180(7):934-943. doi: 10.1001/jamainternmed.2020.0994.