Original Article

Iraqi National Journal of Medicine. January 2026, Volume 8, Issue 1

Evaluation of D-dimer Level in COVID-19 Patients

Amal Malik Hassan[1], Noor Kadhim Mohamed-Jawad[1], Hiba Dawood [1], Ali Adnan Mohsin[2]

[1] University of Basrah, College of Pharmacy, Basrah, Iraq. [2] Basrah Health Directorate, Ministry of Health, Basrah, Iraq.

ABSTRACT

Background: The COVID-19 pandemic is associated with prothrombotic complications, leading to increased morbidity and mortality. D-dimer, a fibrin degradation product, serves as a biomarker for coagulation abnormalities. This study evaluates the role of D-dimer in predicting disease severity and hospitalization in COVID-19 patients. **Aim**: To assess correlations between D-dimer levels and age, gender, comorbidities, disease severity, and hospitalization needs in COVID-19 patients. **Methods**: A retrospective analysis of 78 COVID-19-positive patients admitted to an outpatient clinic was conducted. Data on demographics, comorbidities, vaccination status, disease severity, and admission D-dimer levels were analyzed using statistical tests (t-tests, chi-square, Mann-Whitney U). **Results**: The mean age of participants was 49 years, with 56.4% males and 43.6% females. Approximately 52% of patients had a comorbid disease, primarily hypertension and diabetes. Older patients and those with coexisting diseases had significantly higher D-dimer levels (p-values 0.017 and 0.045, respectively), with non-significant differences between males and females (p-value 0.648). Older patients had a significantly higher need for hospitalization during acute COVID-19 infection (p-value 0.002). Additionally, patients with elevated admission D-dimer levels showed a greater prevalence of severe disease (p-value 0.01) and a higher need for hospitalization (p-value 0.028). **Conclusions**: Elevated admission D-dimer levels are strongly linked to severe COVID-19 outcomes and hospitalization, highlighting their utility as an early prognostic marker. Clinical management of COVID-19 patients may be guided by D-dimer assessment, which may help predict disease severity.

Keywords: COVID-19, D-dimer, prognostic marker, thrombosis, hospitalization, disease severity.

Corresponding author: Amal Malik Hassan. E-mail: Mrs.amalmalik@gmail.com
Disclaimer: The authors have no conflicts of interest.

DOI: https://doi.org/10.37319/iqnjm.8.1.10

Received: 1 JAN 2025 Accepted: 17 JUN 2025 Published online: 15 JAN 2026

INTRODUCTION

The most significant pandemic in contemporary history, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and the ensuing coronavirus disease 2019 (COVID-19), constituted a worldwide public health emergency. This unprecedented spread catalyzed extensive research into the disease's clinical manifestations, underlying mechanisms, pathogenesis, diagnostic approaches, and its multifaceted effects on multiple systems in our bodies.[1,2] According to several previous studies, acute COVID-19 patients are more prone to suffer from dangerous thromboembolic events, and the virus has been linked to an increased risk of cardiovascular problems.[3,4] When SARS-CoV-2 infects host cells, the pathogenic process of thrombosis begins due to an interaction between the host angiotensin-converting enzyme 2 (ACE2) receptor and the spike protein on the virus surface, leading to endotheliatis. The endothelial injury may trigger an immunological reaction

marked by a cytokine storm, which encourages a thrombotic reaction and a hypercoagulable state.[5,6] A fibrin degradation product known as D-dimer is often used as a biological marker for coagulation disorders. A value of less than 0.5 g/mL is generally regarded as a normal D-dimer reading; however, this value rises with age, during pregnancy, malignancy, and pneumonia.[7] In COVID-19 patients, several studies have observed a significant elevation of plasma inflammatory markers, including D-dimer levels, which are linked to severe clinical outcomes such as venous thromboembolism (VTE) and cardiovascular diseases.[8,9] Some studies discovered that an admission D-dimer level exceeding 2.0 g/mL was associated with an increased mortality rate in COVID-19 patients.[10] Other studies found that higher D-dimer levels during admission and higher peak values were associated with deteriorating clinical outcomes, increasing the risk for intubation and death.[11] However, there are few studies evaluating the diagnostic usefulness of D-dimer in predicting disease severity, major coagulation risks, and the outcomes of patients with COVID-19.[12,13] The present study aims to evaluate D-dimer levels in patients with COVID-19 and their possible relation to various factors, including age, gender, comorbidity, disease severity, and need for hospitalization.

MATERIALS AND METHODS

The study was designed as a retrospective analysis with a convenience sampling of data from patients who were admitted to an outpatient clinic and tested positive for COVID-19 from February to November. Patients with chronic thromboembolic diseases, such as deep vein thrombosis (DVT) and pulmonary embolism, those taking chronic thrombolytic medications like warfarin, or those with incomplete laboratory data were excluded from the study. Patient information was recorded, including age, gender, comorbid diseases, number of COVID-19 infections, vaccination status, symptoms, and patient outcomes regarding hospital admission based on their oxygen saturation. D-dimer levels were recorded for all patients included in the study. D-dimer tests were conducted in our laboratory using enzyme-linked immunosorbent assay (ELISA), with a reference range considered normal if less than 500 ng/mL and high if exceeding 500 ng/mL. D-dimer tests during admission were used in the data analysis. Patients were classified into two groups based on disease severity: those with mild to moderate illness treated as outpatients and those with severe disease requiring hospital admission. The severity of COVID-19 was determined by the physician in the outpatient clinic, primarily based on oxygen saturation levels during admission. Patients with decreased oxygen saturation are considered to be severe COVID-19. Additional parameters, such as respiratory rate and ventilation status, were also considered to confirm the assessment of disease severity. The measured parameters were presented statistically as mean and standard deviation (SD) for continuous variables after testing data distribution using the Kolmogorov–Smirnov test and QQ plots. Categorical variables were expressed as numbers (frequency) and percentages. Two-sample independent t-tests were used to compare means of continuous normally distributed variables, while the chi-square test (Fisher Exact test) was used for categorical variables. Non-parametric data were expressed by the median and interquartile range (IQR), with the Mann-Whitney U test used to test non-parametric data. A p-value of less than 0.05, along with a 95% confidence interval (CI), was considered statistically significant.

RESULTS

1. Demographic Data

Seventy-eight patients who tested positive for COVID-19 positive have been included in the study. The participants' mean age was 49 years both males and 43.6% females. Approximately 52% of patients had comorbid diseases, primarily hypertension and diabetes, as shown in Table 1.

Table 1: Demographic data of the patients

Parameter	No. (%)
Age (mean ± SD)	49 ± 16
Gender Male Female	 44 (56.4%) 34 (43.6%)
Comorbidity No chronic disease Diabetes Hypertension Hypertension and diabetes Cardiovascular disease Other	 38 (48.7%) 10 (12.8%) 14 (17.9%) 7 (9%) 3 (3.8%) 6 (7.8%)
COVID-19 Vaccination Non-Vaccinated vaccinated	 46 (59%) 32 (41%)
Severity of Infection Mild-Moderate Severe	 51 (65.4%) 27 (34.6%)

2. D-dimer Level and Patients' Need for hospitalization in Table 2, patients are categorized into two groups depending on their need for hospital admission and compared regarding age, gender, and D-dimer level. Older patients (mean age [95% CI], 56.9 [50.6 to 63.2)) had a significantly higher need for hospitalization during acute COVID-19 infection (p-value 0.002), with non-significant differences between males and females (p-value 0.475). Regarding the need for hospitalization, patients with high admission D-dimer levels were more vulnerable to COVID-19 complications and required hospitalization. The median D-dimer level in hospitalized patients was 800 ng/mL, which was higher than the median D-dimer level (300 ng/mL) in the non-hospitalized group (p-value 0.028).

3. Relation of D-dimer with Age, Gender, Comorbidity, and COVID-19 Severity in Table 3, two groups of patients were compared based on D-dimer levels, categorized as normal (less than 500 ng/mL) or elevated (more than 500 ng/mL), regarding age, sex, comorbidity, and disease severity. Older patients and those with coexisting diseases had significantly higher D-dimer levels (p-values 0.017 and 0.045, respectively), with non-significant differences between males and females (p-value 0.648). Regarding disease severity (Fig. 1), patients with higher D-dimer levels were more likely to develop severe COVID-19 compared to those with normal D-dimer levels (p-value 0.01).

4. COVID-19 Vaccination and D-dimer Level in Table 4, patients are categorized into two groups based on COVID-19 vaccination status. Vaccinated patients had a lower median D-dimer level (377 ng/mL) compared to non-vaccinated patients (565 ng/mL). However, non-significant differences were observed between the two groups (p-value 0.396).

Table 2: D-dimer level and patients' need for hospitalization

Parameter	Not Needing Hospitalization	Needing Hospitalization	p-Value	Statistical Test
Age (mean [95% CI])	45.1 (41.0- 49.2)	56.9 (50.6- 63.2)	0.002*	Independent Sample t-test
Gender No. (%) Male Female	 27 (61.4%) 24 (70.6%)	 17 (38.6%) 10 (29.4%)	0.475	Chi-square
D-dimer Median (IQR)	300 ng/mL (800)	800 ng/mL (1654)	0.028*	Independent-Samples Mann-Whitney U Test
*p-value < 0.05 considered statistically significant				

Table 3: Relation of D-dimer with Age, Gender, Comorbidity, and COVID-19 Severity

Parameter	Normal D-dimer Level	High D-dimer Level	p-value	Test
Age (mean [95% CI])	45.2 (40.5 to 49.9)	53.8 ± 16 (48.4 to 59.2)	0.017*	Independent t-test
Sex (No. %) Male Female	 25 (56.8%) 17 (50%)	 19 (43.2%) 17 (50%)	0.648	Chi-Square
Comorbidity (No. %) No Yes	 25 (65.8%) 17 (42.5%)	 13 (34.2%) 23 (57.5%)	0.045*	Chi-square
Severity (No. %) Mild-Moderate Severe	 33 (64.7%) 9 (33.3%)	 18 (35.3%) 18 (66.7%)	0.01*	Chi-Square
*p-value < 0.05 considered statistically significant				

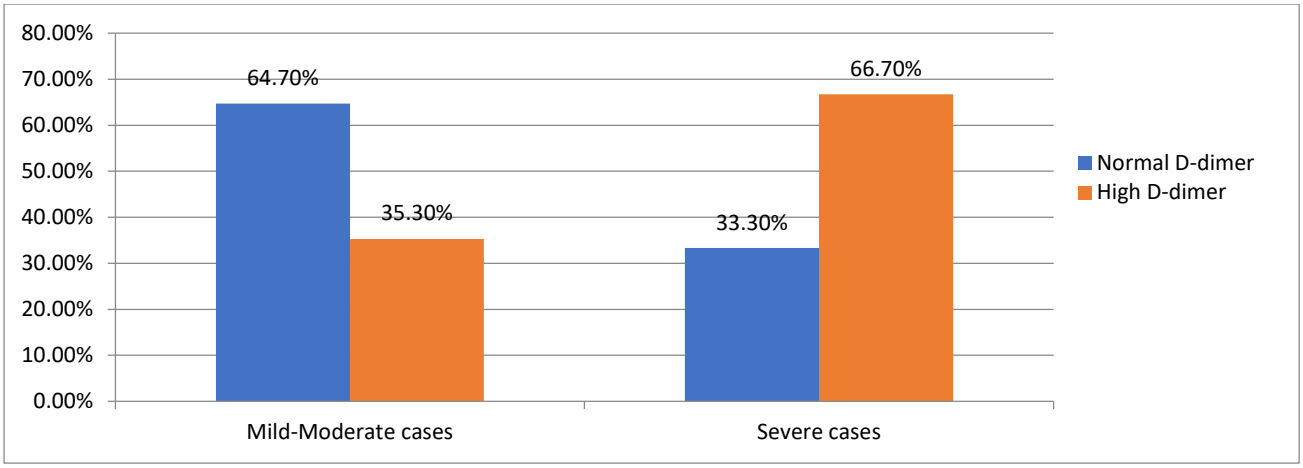

Figure 1: Distribution of D-dimer levels in mild-moderate cases versus severe cases

Table 4: COVID-19 vaccination and D-dimer level

Parameter	Non-vaccinated Patients	Vaccinated patients	p-Value	Statistical test
D-dimer Level Median (IQR)	565 ng/mL (814)	377 ng/mL (919)	0.396	Independent-Samples Mann-Whitney U Test

DISCUSSION

A newly emerged viral disease called COVID-19 is rapidly spreading around the world. There has been a link between COVID-19 and the risk of thrombosis. This research aimed to study the usefulness of D-dimer as a biomarker for clinical outcomes and disease severity. The demographic characteristics (Table 1) of patients revealed that the average age of COVID-19 patients is middle-aged, consistent with other studies showing an increase in severity with advancing age.[14] The large proportion of unvaccinated patients (59%) provides insight into the population dynamics regarding COVID-19 protection and highlights the critical role of vaccination in controlling COVID-19 outcomes. The distribution of COVID-19 patient severity in this study is comparable to that reported by other studies.[15,16] In Table 2, age and hospital admissions were significantly correlated. This result agrees with a retrospective study by Ioannou et al., which found that older individuals have a higher risk of developing serious illnesses, complications, and mortality due to COVID-19. Age-related changes in the body, such as hormonal changes and decreased respiratory mucociliary clearance, may contribute to this increased risk. Furthermore, infection with SARS-CoV-2 might cause a drop in ACE2 protein levels, which may enhance the expression of pro-inflammatory mediators' expression, resulting in aggravated COVID-19 severity and a higher mortality rate. This is particularly crucial for older patients, who are more susceptible to the immunologic effects of the decrease in ACE2 levels caused by SARS-CoV-2, as ACE2 levels decline with age.[17,18] In this research, the need for hospital admission did not significantly correlate with gender. This result disagrees with other studies indicating that found males are more likely to require respiratory intubation, resulting in longer hospital stays and a high death rate.[19] D-dimer was significantly associated with the requirement for hospital admission. This result aligns with other studies showing that D-dimer levels are frequently higher in SARS-CoV-2-infected patients. Critically ill patients had substantially higher levels.[20], which can be used as predictors of inpatient hospital

mortality.[7,10] The study by Ali et al. reported that the need for invasive mechanical ventilation was independently linked with high D-dimer levels. Berger et al. found that among patients with COVID-19, D-dimer levels were independently linked to a greater risk of critical illness, thrombosis, acute renal injury, and all-cause mortality.[21] The D-dimer test is frequently used in laboratories to assess thrombotic events. D-dimer levels were also shown to be higher in non-survivors than in survivors, and patients with high D-dimer levels had a 1.82-fold higher probability of dying compared to other patients.[22] Currently, there is insufficient information to determine whether the causes are brought on specifically by the infection with SARS-CoV-2 or by a general inflammatory reaction. The aggravation of lung pathology in SARS-CoV-2 infection is caused by dysregulation of the coagulation and anticoagulation cascades.[7] D-dimer may serve as an early and valuable marker to assist in better COVID-19 patient management.[10] In (Table 3), elevated D-dimer levels were significantly correlated with age. This finding agrees with prior studies, which showed that the risk of thrombotic problems in COVID-19 infection is higher in older individuals.[17,23-25] Regarding comorbidities, this study found a statistically significant association between comorbidities and increased D-dimer levels. This result is consistent with other studies that diabetics with COVID-19 are more prone to experience hypercoagulation, which has a poor prognosis. Another study it was shown that diabetics possess higher prevalences of chronic obstructive pulmonary diseases (COPD), interstitial lung diseases, and hypertension. These results may further increase the likelihood of these individuals contracting COVID-19. Comorbidities caused by viral infections can exacerbate the illness and sometimes lead to death. The study by Yang et al. found that in COVID-19 patients, hypertension, elevated D-dimer, and the ratio of neutrophils to lymphocytes all contributed to higher mortality rates. The study by Amay et al. found that in hypertensive patients with high D-dimer levels, mortality was approximately three times higher.[1,25,29] An additional finding was a statistically significant connection between high levels of D-dimer and COVID-19 disease severity. This result closely aligns with previous studies showing that D-dimer levels were significantly greater in COVID-19 individuals with severe illness compared to those with less severe disease, and levels of D-dimer greater than 0.5 µg/mL are linked to severe COVID-19 infection. A viral infection has the potential to develop into sepsis and disrupt coagulation, which is a common symptom in serious cases. Moreover, inflammatory cytokines can alter the balance of coagulation and fibrinolysis in the alveoli, which might activate the fibrinolysis system and raise D-dimer levels; the increase in D-dimer levels may be an indirect indicator of inflammation.[25,30-35] An increased likelihood of a severe course of the disease was associated with elevated D-dimer levels in hospitalized patients. These results highlight the significance of D-dimer levels as an early prognostic biomarker that may be able to predict the severity and outcomes of COVID-19 patients' illnesses. Finally, there was no significant correlation between being vaccinated against COVID-19 and increased D-dimer levels. A previous study reported that thrombosis can occur in SAR-CoV-2 patients and, very rarely, in people who have received the SARS-CoV-2 vaccine. [36]

CONCLUSIONS

Hospitalized individuals with elevated D-dimer levels were more likely to experience severe illness progression. These findings demonstrate the value of D-dimer as an early prognostic biomarker for forecasting the course and severity of COVID-19 patients' illnesses. Further studies with larger cohorts are needed to validate these findings.

Limitations:

Differences in measurement tools for D-dimer and varying treatment protocols may affect the generalizability of the results. Further longitudinal studies involving larger sample sizes and diverse populations are required to confirm the results.

REFERENCES

1. Mohamed-Jawad NK, Hassan AM, Qasim SK. Assessment of Post-COVID-19 Syndrome and Its Relationship to Age, Sex, and Comorbid Disease in the Iraqi Population. *Med J Babylon*. 2025;22(1):33–40. doi: 10.4103/MJBL.MJBL_107_23.
2. Kostoff RN, Briggs MB, Kanduc D, Dewanjee S, Kandimalla R, Shoenfeld Y, et al. Modifiable Contributing Factors to COVID-19: A Comprehensive Review. *Food Chem Toxicol*. 2023;171:113511. doi: 10.1016/j.fct.2022.113511.
3. Sewanan LR, Clerkin KJ, Tucker NR, Tsai EJ. How Does COVID-19 affect the Heart? *Curr Cardiol Rep*. 2023;25:171–184. doi: 10.1007/s11886-023-01841-6.

4. Khan MZ, Jamal Y, Sutton B, Rauf F. Venous Thromboembolism in patients with COVID-19 and Correlation with D-dimers: Single-Center Experience. *BMJ Open Respir Res*. 2020;7(1):e000779. doi: 10.1136/bmjresp-2020-000779.
5. Sastry S, Cuomo F, Muthusamy J. COVID-19 and Thrombosis: The role of Hemodynamics. *Thromb Res*. 2022;212:51–57. doi: 10.1016/j.thromres.2022.02.016.
6. Connors JM, Levy JH. COVID-19 and Its Implications for Thrombosis and anticoagulation. *Blood*. 2020;135(23):2030–2040. doi: 10.1182/blood.2020006000.
7. Yao J, Cao J, Wang Q, Shi Q, Liu K, Luo Z, et al. D-dimer as a Biomarker for disease severity and Mortality in COVID-19 Patients: A Case-Control Study. *J Intensive Care*. 2020;8:49. doi: 10.1186/s40560-020-00466-z.
8. Li Y, Zhao K, Wei H, Chen W, Wang W, Jia L, et al. Dynamic Relationship Between D-dimer and COVID-19 Severity. *Br J Haematol*. 2020;190(1):e24–e27. doi: 10.1111/bjh.16811.
9. Fang P, Du L, Cai D. Evaluation of Plasma D-dimer for the Diagnosis in Chinese Patients with Hepatocellular Carcinoma: a meta-analysis. *Medicine (Baltimore)*. 2020;99:e19461. doi: 10.1097/MD.0000000000019461.
10. Zhang L, Yan X, Fan Q, Liu H, Liu X, Liu Z, et al. D-dimer Levels on admission to Predict In-Hospital Mortality in Patients with COVID-19. *J Thromb Haemost*. 2020;18(6):1324–1329. doi: 10.1111/jth.14859.
11. Nemec HM, Ferenczy A, Christie BD 3rd, Ashley DW, Montgomery A. Correlation of D-dimer and Outcomes in COVID-19 Patients. *Am Surg*. 2022;88(9):2115–2118. doi: 10.1177/00031348221091940.
12. Zhan H, Chen H, Liu C, Cheng L, Yan S, Li H, et al. Diagnostic Value of D-Dimer in COVID-19: A Meta-Analysis and Meta-Regression. *Clin Appl Thromb Hemost*. 2021;27:10760296211010976. doi: 10.1177/10760296211010976.
13. Paliogiannis P, Mangoni AA, Dettori P, Nasrallah GK, Pintus G, Zinellu A. D-Dimer Concentrations and COVID-19 Severity: A Systematic Review and Meta-Analysis. *Front Public Health*. 2020;8:432. doi: 10.3389/fpubh.2020.00432.
14. Barek MA, Aziz MA, Islam MS. Impact of Age, Sex, Comorbidities, and Clinical Symptoms on the Severity of COVID-19 Cases: A meta-analysis with 55 Studies and 10014 cases. *Heliyon*. 2020;6(12):e05684. doi: 10.1016/j.heliyon.2020.e05684.
15. Thakur B, Dubey P, Benitez J, Torres JP, Reddy S, Shokar N, et al. A Systematic Review and Meta-Analysis of Geographic Differences in Comorbidities and Associated Severity and Mortality Among Individuals with COVID-19. *Sci Rep*. 2021;11:8562. doi: 10.1038/s41598-021-88130-w.
16. He X, Cheng X, Feng X, Wan H, Chen S, Xiong M. Clinical Symptom Differences Between Mild and Severe COVID-19 patients in China: A Meta-Analysis. *Front Public Health*. 2021;8:561264. doi: 10.3389/fpubh.2020.561264.
17. Ioannou P, Spentzouri D, Konidaki M, Papapanagiotou M, Tzalis S, Akoumianakis I, et al. COVID-19 in Older Individuals Requiring Hospitalization. *Infect Dis Rep*. 2022;14:686–693. doi: 10.3390/idr14040092.
18. Medetalibeyoglu A, Senkal N, Kose M, Catma Y, Caparali EB, Erelel M, et al. Older Adults Hospitalized with COVID-19: Clinical Characteristics and Early Outcomes from a Single Center in Istanbul, Turkey. *J Nutr Health Aging*. 2020;24(9):928–937. doi: 10.1007/s12603-020-1371-2.
19. Nguyen NT, Chinn J, De Ferrante M, Kirby KA, Hohmann SF, Amin A. Male Gender is a Predictor of higher mortality in Hospitalized Adults with COVID-19. *PLoS One*. 2021;16(7):e0254066. doi: 10.1371/journal.pone.0254066.
20. Ali A, Liang W, Abdelhafiz AS, Saleh MM, Salem H, Moazen EM, et al. Elevation of D-dimer Levels is associated with Early Need for Mechanical Ventilation Support in Patients with COVID-19. *BMC Pulm Med*. 2023;23:283. doi: 10.1186/s12890-023-02139-y.
21. Berger JS, Kunichoff D, Adhikari S, Ahuja T, Amoroso N, Aphinyanaphongs Y, et al. Prevalence and Outcomes of D-dimer Elevation in hospitalized patients with COVID-19. *Arterioscler Thromb Vasc Biol*. 2020;40(10):2539–2547. doi: 10.1161/ATVBAHA.120.314872.
22. Gungor B, Atici A, Baycan OF, Alici G, Ozturk F, Tugrul S, et al. Elevated D-dimer Levels on admission are Associated with severity and Increased Risk of Mortality in COVID-19: A Systematic Review and Meta-Analysis. *Am J Emerg Med*. 2021;39:173–179. doi: 10.1016/j.ajem.2021.01.053.
23. Sharp K, Ghodke B. D-dimer Levels in COVID-19 Patients and Its Correlation with Age and gender: a retrospective analysis. *Int J Res Rev*. 2020;7(7). doi: 10.5281/zenodo.3982489.
24. Yuan X, Tong X, Wang Y, Wang H, Wang L, Xu X. Coagulopathy in Elderly Patients with Coronavirus Disease 2019. *Aging Med (Milton)*. 2020;3:260–265. doi: 10.1002/agm2.12152.
25. Salah-Elden MI, El-Bolkiny YE, Hantera ME, Eid MA. CRP, D-dimer, and Comorbidities as Potential Prognostic Factors in Critically Ill COVID-19 Patients. *J Clin Basic Res*. 2024;8(1):41–51. doi: 10.21608/JCBR.2024.264046.1335.
26. Miri C, Charii H, Bouazzaoui MA, Brem FL, Boulouiz S, Abda N, et al. D-dimer Level and diabetes in COVID-19 Infection. *Clin Appl Thromb Hemost*. 2021;27:1–4. doi: 10.1177/1076029621992212.
27. Mishra Y, Pathak BK, Mohakuda SS, Sen S, Harikrishnan P, Singh R, et al. Relation of D-dimer Levels of COVID-19 Patients with Diabetes Mellitus. *Diabetes Metab Syndr Clin Res Rev*. 2020;14:1927–1930. doi: 10.1016/j.dsx.2020.08.016.
28. Yang Q, Zhou Y, Wang X, Gao S, Xiao Y, Zhang W, et al. Effect of Hypertension on Outcomes of adult inpatients with COVID-19 in Wuhan, China: A Propensity Score Matching Analysis. *Respir Res*. 2020;21:172. doi: 10.1186/s12931-020-01462-4.
29. Amay V, Sugeng C, Umboh O, Moeis E. Association of D-Dimer and Fibrinogen Level with Mortality of hypertensive COVID-19 Patients. *J Hypertens*. 2021;39:e20. doi: 10.1097/HJH.0000000000002786.
30. Yu HH, Qin C, Chen M, Wang W, Tian DS. D-dimer Level is associated with the Severity of COVID-19. *Thromb Res*. 2020;195:219–225. doi: 10.1016/j.thromres.2020.06.045.
31. Nasif WA, Ali ASE, Mukhtar MH, Alhuzali AMH, Alnashri YAY, Gadah ZIA, et al. Elucidating the Correlation of D-dimer Levels with COVID-19 Severity: A Scoping Review. *Hindawi Anemia*. 2022. doi: 10.1155/2022/3287862.
32. Varikasuvu SR, Varshney S, Dutt N, Munikumar M, Asfahan S, Kulkarni PP. D-dimer, Disease Severity, and Deaths (3D-study) in Patients with COVID-19: A Systematic Review and Meta-Analysis of 100 Studies. *Sci Rep*. 2021;11:21888. doi: 10.1038/s41598-021-01262-6.
33. Du WN, Zhang Y, Yu Y, Zhang R. D-dimer Levels are Associated with Severe COVID-19 infections: A Meta-Analysis. *Int J Clin Pract*. 2021;75(8):e14031. doi: 10.1111/ijcp.14031.
34. Al-Jumaili EF, Zaeel AA. Correlation of D-dimer with the Severity of COVID-19 in a Sample of Iraqi Patients in Diyala Governorate. *J Port Sci Res*. 2024;7(special):30–33. doi: 10.36371/port.2024.special.5.

35. Elfeky HM, Helal SM, El-Moazen MS, Sultan WA. Association Between D-Dimer Level and Severity of COVID-19 Infection. *Egypt J Hosp Med*. 2024;97:3995–4002. doi: 10.21608/ejhm.2024.391847.
36. Violi F, Cammisotto V, Pastori D, Pignatelli P. Thrombosis in Pre- and post-vaccination phase of COVID-19. *Eur Heart J Suppl*. 2021;23(Suppl E):E184–E188. doi: 10.1093/eurheartj/suab042.