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Laboratory Findings in Covid-19 Diagnosed Patients in a Tertiary Hospital in Ghana : A Retrospective Analysis

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Abstract

In order to diagnose COVID-19, severe acute respiratory syndrome-Corona Virus-2 (SARS-CoV-2) must be positively identified. When the epidemic first began, medical personnel had little understanding of the condition and course of treatment for COVID-19 patients. The World Health Organization (WHO) recommended that it is important to have laboratory attached to management. In order to analyze the various laboratory findings in COVID-19 diagnosis observed at the Isolation Centre of the Fevers Unit of Korle-Bu Teaching Hospital, a retrospective analysis study of various documented laboratory results captured. A total of 54 patients were hospitalized at the COVID-19 ICU of the Korle-Bu Teaching Hospital. Women accounted for 57% (31/54) positivity and men, 43% (23/54). The mean (SD) age was 47.1(17.9) years. The age distribution showed that the largest percentage of people, 26.4% (14/54), were in the 60+ age group, followed by the 40-49 age group (22.6%) (12/54), and the 30-39 age group (18.9% (10/54).Over 56% of patients had hypertension, making it the most prevalent disease condition. Hematological parameters like HB for patients (n=24) were 10.5±2.5, cardiac parameters like albumin for patients (n=18) were 24.4±13.7, and biochemical parameters like ALT for patients (n=21) were 63.21 ±65. Inflammatory parameters, like CRP (n=12), recorded a mean of 23.5, while coagulation parameters, like D-DIMER, for patients (n=18) were 4.7±8.4.According to the list of comorbidities noted, the kidney, lungs, and liver were the organs most affected in the study.

Keywords: SARS-CoV-2 Coronavirus COVID-19, Laboratory findings, Prognosis, Korle-Bu.

Introduction

In order to diagnose Coronavirus disease, Severe Acute Respiratory Syndrome-Corona Virus-2 (SARS-CoV-2) must be positively identified. When the epidemic first began, medical personnel had little understanding of the condition and course of treatment for COVID-19 patients. This increased the likelihood of receiving false negative results. Clinical signs of the disease, as well as the World Health Organization's (WHO) efforts to develop an accurate diagnosis for the disease, led to the conclusion that certain laboratory markers were required for disease identification over time.

According to a WHO COVID-19 situation report, the first cases of COVID-19 in humans were reported by Wuhan City officials in December 2019 (World Health Organization [WHO], 2020).

SARS-CoV-2, the virus that causes Covid-19, is an enveloped RNA (ribonucleic acid) virus from the Coronaviridae family. COVID-19 is spread through contaminated surfaces or respiratory droplets (Karimi et al., 2021). Ghana had her first COVID-19 recorded on 12th March, 2020. This was based on a report from Ghana Health Service, which indicated that 2 persons who had returned from Norway and Turkey respectively tested positive for COVID-19 prior to the laboratory results from the Noguchi Memorial Institute for Medical Research (NMIMR) (Agormedah et al., 2020). However, the COVID-19 increased from 2 to 4 the next day and from 4 to 6 on 14th of March in the same year. On the 15th of March 2020, the country recorded additional four cases which resulted in a total of 10 confirmed cases. The Korle Bu Teaching Hospital (KBTH) was one of the designated treatment sites for Covid-19 patients. The KBTH designated the Fevers unit and refurbished a 7-bed capacity site solely to treat COVID-19 patients. In May 2020, the unit became fully operational with different healthcare professionals posted there to manage Covid-19 patients. It became known as the isolation unit of COVID-19 patients at the hospital.

When SARS-CoV-2 virus is inhaled, it binds to epithelial cells in the nasal cavity and begins to replicate. The main receptor for the virus (SARS-CoV2) is Angiotensin Converting Enzyme 2 (ACE2). At this stage the virus can be detected by nasal swabs. Persons with low viral load are infectious in this stage. The diagnostic tool to detect and predict the viral load is Reverse transcription polymerase chain reaction (RT-PCR) by taking nasal or throat swabs from suspected persons. Within few days, the virus disseminates and move down to the respiratory tract. This action triggers the innate immune system. Any swabs taken at this stage would yield innate immune response markers and COVID-19 manifestations clinically (Mason, 2020). Accompanying traits include pneumonia, fever, non-productive cough and asthenia, Nausea, vomiting, and dyspnea are also reported in patients with COVID-19, although these are less common (Jin et al., 2021; Wu & McGoogan, 2020). However, patients with severe disease may develop Acute Respiratory Distress Syndrome (ARDS), acute cardiac injury, shock and can require invasive ventilation (Cao et al., 2021). The appropriate analysis of the laboratory characteristics associated with COVID-19 can assist with clinical diagnosis and prognosis (Li et al., 2020).

The present study thus investigated the laboratory findings of COVID-19 diagnosed adult patients, the clinical significance of the biomarkers elevated or decreased in the subjects and their target organs involved. This study draws a relationship between prognostic and diagnostic values of the laboratory findings involved and give interpretation to the results.

Methods

This was a retrospective study carried out by collecting the intervened and recommended documentations of laboratory findings or outcomes of patients who were admitted at the Isolation Centre of the Fevers Unit of Korle-Bu Teaching Hospital from the period May 2020 to August 2020 at the peak of the pandemic in Ghana using the Ministry of Health recommended data collection forms.

Two independent reviewers collected and evaluated the data regarding laboratory data and clinical outcomes of the patient (see tables for data). We extracted data of the sample size and calculated mean values and standard deviations (SD) of the reported biomarkers. Laboratory findings were categorized into coagulation parameters, hematological parameters, serum electrolyte parameters, cardiac parameters, inflammatory parameters and biochemical parameters. Comparison of mean and SD values of the laboratory markers were gender based.

All the clinical data on epidemiology which includes, recent exposure history, signs and symptoms, underlying comorbidities and laboratory results were retrospectively extracted from electronic medical Records. Data were entered into Excel and descriptive statistics of parameters were obtained before exporting to STATA® version 15 to determine associations and statistical summaries of the variables.

Ethical Approval

Ethical approval was obtained from Accra Technical University with Protocol Identification Number (PIN): ATU/MLT/ET/01180244B/2021-202.

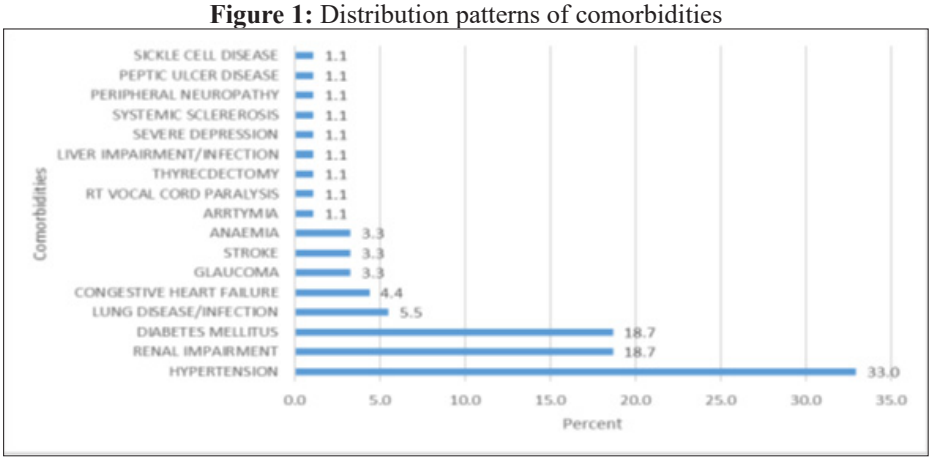
Results

All patients were confirmed positive for COVID-19 infection positivity twice before being placed on admission. A total of 54 patients were hospitalized at the COVID-19 ICU of the Korle-Bu Teaching Hospital during this study period from May 2020 to August 2020. Women accounted for 57% (31/54) positivity and men 43% (23/54) of the patients during the study period. The mean (SD) age was 47.1(17.9) years. Per the age distribution, the 60+ years age group accounted for 26.4% (14/54), which is the highest followed by 40-49 age group 22.6% (12/54), then 30-39 years' group 18.9% (10/54).

Patients' Characteristics

There were almost 21 various types of diseases or comorbidities recorded among the 54 patients. The highest number of comorbidities per patient was five (5) whilst the lowest was none. Impaired metabolic health, such as hypertension and diabetes, were very prevalent in this study. Hypertension was the most common cardiovascular disease, affecting more than 56% of the patient population in the study. Renal impairment and diabetes, respectively, accounted for 32% each. The rest of the characteristics of the various comorbidities recorded are shown in figure 1.

Figure 1: Distribution patterns of comorbidities



A little over half (54%, n=29) of the patients undertook the Na+ test. Of this number,15 of them were females and 14 of them were males. Twenty-eight (n=28) patients did the K+ test and the distribution was shared equally beween the males and females, 14 each.The rest of the tests were done by half or less of the patients on admission with no one doing cholerstrol and HbA1C see figure 2.

Out of the total, 57% (n=31) were females and 43% (n=23) were males. Of the number, less than half (44.4%, n=24) undertook the Hemoglobin test. 66% (n=14) of them were females.

Figure 2: Distribution of Tests Undertaken by Gender

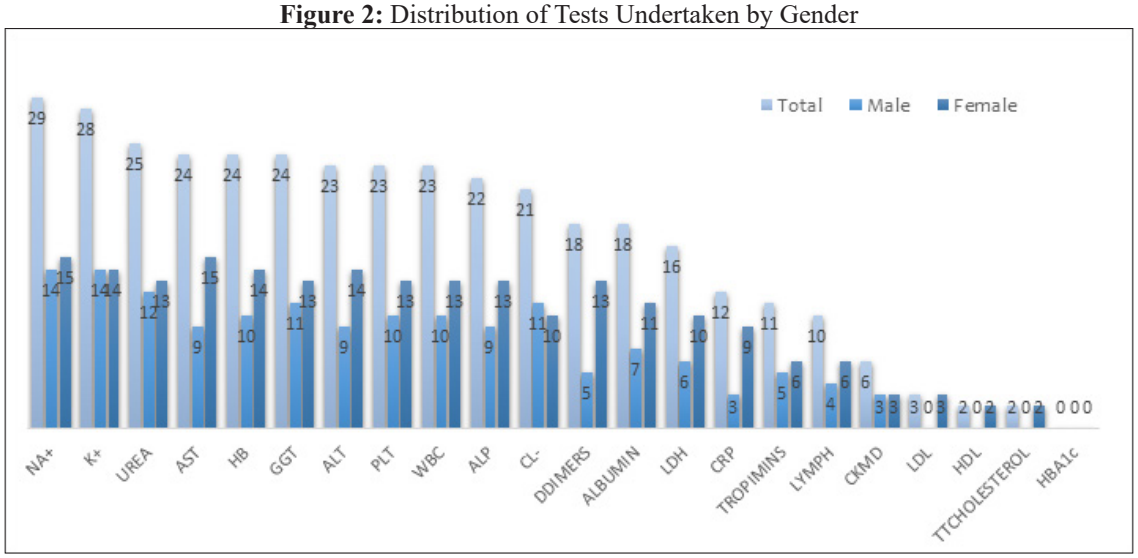


Table 1: Summary statisitcs of Inflamatory variables on patients

Gender	Mean	SD	N	Min	Max
Female					
CRP	21.5	32.4	9	0.33	95
LDH	408.0	167.3	10	157	611
Male					
CRP	29.7	46.1	3	0.23	82.78
LDH	313.7	258.1	6	6	746
Total					
CRP	23.5	34.1	12	0.23	95
LDH	372.6	203.1	16	6	746

REFERENCE RANGES: CRP [<8.0mg/L], LDH [<110-210IU/L, cut off 280IU/L]

Table 2: Summary statistics of coagulation variables of patients

Gender	Mean	SD N%	N	Min	Max
Female					
D-DIMERS	↑2.3	2.5 32	13	0.1	7.7
CRP	↑21.5	32.4 29	9	0.3	95.0
Male					
D-DIMERS	↑10.9	14.5 22	5	0.3	35.3
CRP	↑29.7	46.1 13	3	0.2	82.8
Total					
D-DIMERS	↑4.7	8.4 54	18	0.1	35.3
CRP	↑23.5	34.1 42	12	0.2	95.0

REFERENCE RANGES: D-dimer [0.22-0.46ug/ml], CRP [<8.0mg/l]

Coagulation Parameters

The mean D-DIMER for all the patients (n=18) is 4.7±8.4, the minimum is 0.1 and the maximum is 35.3. For females (n=13) the average is 2.3±2.5 with a minimum of 0.1 and a maximum value of 7.7. However, the mean for the males (n=5) is 10.9±14.5, with the lowest value of 0.3 and as high as 35.3 See table 2

Hematological parameters

The mean HB for the patients (n=24) was 10.5±2.5, the minimum value was 4.2 and the maximum value was 14.6. The females (n=14) had a mean of 10.1±2.4, lowest at 4.2 and highest value at 13.0, for the males (n=10) the average is 11.0±2.4, with a minimum of %% 7.4 and as high as 13.0. The mean WBC was 10.9±7.0, a minimum of 2.7 and a maximum of 32.2. However, the females (n=13) the mean is 13.2±8.3, as well as 7.9±3.4 for the males (n=10). Lymph (n=10) has a mean of 2.9±4.4, the average female (n=6) lymph is 1.4±0.7 and the average male (n=4) is 5.1±6.8. The mean PLT is 340.7±206.8 for all patients (n=23), the minimum is 32.3 and the maximum is 766. For the females (n=13), the mean is 388.8±243.3 and 278.2±134.1 for the males (n=10). (See table3).

Table 3: Summary statistics of hematological parameters of patients

Gender	Mean	SD%	N	Min	Max
Female					
PLT	↑388.8	243.3 42	13	32.3	766.0
LYMPH	↓1.4	0.7 19	6	0.5	2.4
WBC	↑13.2	8.3 42	13	2.7	32.2
HB	↓10.1	2.4 45	14	4.2	13.0
Male					
PLT	↑278.2	134.1 43	10	59.1	441.0
LYMPH	↓5.1	6.8 17	4	1.3	15.2
WBC	7.9	3.4 43	10	4.4	16.1
HB	↓11.0	2.6 43	10	7.4	14.6
Total					
PLT	↑340.7	206.8 85	23	32.3	766.0
LYMPH	↓2.9	4.4 36	10	0.5	15.2
WBC	10.9	7.0 85	23	2.7	32.2
HB	↓10.5	2.5 88	24	4.2	14.6

REFERENCE RANGES: PLT [>250×10^9/L], LYMPH [>5.1×10^9/L], WBC [4.0-11.0×10^9/L], HB [females= 12.0-15.0g/dl, males= 13.0-18.0g/dl]

Cardiac Parameters

The mean ALBUMIN for the patients (n=18) was 24.4±13.7, with a minimum range of 2.7 and a maximum of 42. The female average (n=14) was 54.6±50.5 and the male average (n=7) was 27.5±10.4. CK-MB has a mean of 109±155.3 (n=6) with a minimum of 3 and a maximum of 399 among the patients who took this test. For the females (n=3) the average was 19.7±14.6 and for the males (n=3) the mean was 198.3±190.1 (See table 4).

Table 4: Summary statistics of cardiac parameters of patients

Gender	Mean	SD%	N	Min	Max
Female					
CK-MB	↑19.7	14.6 10	3	3	30
ALBUMIN	↓22.4	15.6 35	11	2.7	42
Male					
CK-MB	↑198.3	190. 10	3	21	399
ALBUMIN	↓27.5	10.4 30	7	4.6	34
Total					
CK-MB	↑109.0	155. 20	6	3	399
ALBUMIN	↓24.4	13.7 65	18	2.7	42

REFERENCE RANGES: CK-MB [females= 5.0ng/l, males= 13ng/l], Albumin [3.4-5.4g/dl or 34-54g/l]

Electrolyte Parameters

Sodium was observed in 29 of the patients with a low-level count of 4.2 u/l and as high as 146u/l per patient's blood sample. The mean Na+ value was 129.6±25.3.

For females (n=15) the mean was 125±34.9 and slightly higher in males (n=14, 134.6±4.2).

The average potassium level per patient (n=28) was 4.92 ±1.29 within a range of 8.4 and 3.2 closely. Chlorine was observed in (n=21) patients and the values range from as low as 14 to a high level of 113 (See table 5).

Table 5: Summary statistics of serum electrolyte parameters of patients

Gender	Mean	SD%	N	Min	Max
Female					
Na^+	↓125.0	34.9 48	15	4.2	146
K^+	↑5.4	1.3 45	14	3.4	8.4
Cl^-	↓92.8	28.2 32	10	14	113
Male					
Na^+	↓137	4.2 61	14	124	139
K^+	4.5	1.1 61	14	3.2	6.9
Cl^-	↓94.3	5.7 48	11	85	103
Total					
Na^+	↓129.6	25.3	29	4.2	146
K^+	4.9	1.3	25	3.2	8.4
Cl^-	↓93.6	19.4 80	21	14	113

REFERENCE RANGES : Na^+ [135-145mmol/l], K^+ [3.5-5.0mmol/l], Cl^- [95-105mmol/l]

Biochemical Parameters

Even though a normal ALT test result can range from 7 to 55 units per liter (U/L), the average of the 21 people was 63.21 ±65.25, the lowest was 11, and the highest was around 282 which is way quite risky. The average was higher in males (n=9, 76.56±85.03) compared to females (n=14, 54.64±50.52). The average ALP level is quite high with an average of 154.91 in (n=14) patients. It could decrease to as low as 43 and be as high as 760, with a constant difference of 149 for females (n=13) the mean is 130.3±68.7 and for the males (n=9) the average is 190.4±220.9.

AST has an overall mean of (n=24, 85.4±89.3) with a minimum of 2.1 and a maximum of 340u/l in patients admitted. For the females (n=15), the average is 88.5±98.6. But for the males (n=9), the mean is 80.2±77.1.

For LDL, the mean is (3.23±2.1, n=3) with a minimum of one can be as high as 5.37. All three who tested for LDL were females and hence no data for males. TT CHOLESTEROL has a mean of (n=2, 52.1±73.1) for the two persons who tested for it. However, all of them were females. For GGT, the average was (112.0±97.9, n=23), with a minimum of 29 and maximum of 482.The mean GGT for females (n=13) is 117.2±124 and that of the males (n=10, 105.2±53.3). Urea level was observed with an average of 11.4±11.3 in 25 patients. The minimum was 2 and the maximum of 40. Females (n=13) had an average of 6.7 while the males (n=12) had an average of 16.5±14.3.

Table 6: Summary statistics of Biochemical parameters of patients

Gender	Mean	SD%	N	Min	Max
Female					
ALP	↑130.3	68.7 42	13	43	227
ALT	↑54.6	50.5 45	14	12	207
LDL	↓3.2	2.1 10	3	1	5
TTCHOLESTROL	↑52.1	73.5 6	2	0	104
GGT	↑117.2	124 42	13	34	482
UREA	6.7	4.3 42	13	3	19
HbA1C	.	.	0	.	.
AST	↑88.5	98.6 48	15	2.1	240
Male					
ALP	↑190.4	221 39	9	56	760
ALT	↑176.6	85.0 39	9	11	282
LDL	.	. -	0	.	.
TTCHOLESTROL	.	. -	0	.	.
GGT	↑105.2	53.3 43	10	29	211
UREA	16.5	14.3 52	12	2	40
HbA1C	.	. -	0	.	.
AST	↑80.2	77.1 52	9	12	234
Total					
ALP	↑154.9	149 81	22	43	760
ALT	↑63.2	65.2 84	23	11	282
LDL	↓3.2	2.1 10	3	1	5
TTCHOLESTROL	↑52.1	73.5 6	2	0	104
GGT	↑112.0	97.9 85	23	29	482
UREA	11.4	11.3 94	25	2	40
HbA1C	.	.	.	.	.
AST	↑85.4	89 100	24	2.1	340

REFERENCE RANGES: ALP [30-130U/L], ALT [females=19-25IU/L, males= 29-33IU/L, AST [females=9-32IU/L, males= 29-33IU/L], LDL [3.4mmol/l], TT-CHOLESTEROL [5.2mmol/l], GGT [8-38IU/L], Urea [2.8-7.2mmol/l], HbA1C [5.7-6.4% prediabetes, above 6.5% diabetes]

Discussion

In this study, we aimed to look at the importance of laboratory findings in the management of hospitalized COVID-19 patients via a complete review, analysis and summary of laboratory results/ findings of adult hospitalized patients.

A similar study by Liu et al. (2020) had corresponding disease patterns and results. The mean age and percentage of males and females in this research is similar to other published literature related to COVID-19 diagnosis (Ofei-palm et al., 2022). The most prevalent comorbidity in this study was hypertension, which was reported similar study (Mason, 2020; Chen et al., 2020).

Per the age distribution, the 60+ years age group accounted for 26.4% (14/54), which is the highest followed by 40-49 age group 22.6% (12/54), then 30-39 years' group 18.9% (10/54). The major population in the age group of 40-60+ years could be contributory to the increased comorbidities and severity in biomarkers. The correlation between the age and severity of disease may be due to weaker immune systems and account for more comorbidities in older patients. Therefore, people with comorbidities, such as hypertension, diabetes, coronary heart disease, and the aged, appear to have a higher risk for COVID-19 as reported in many studies (Meng et al., 2021; Goudouris, 2021; Statsenko et al., 2021).

Out of the 31 females, 29% (n=9) who tested for inflammatory marker C-reactive protein (CRP) presented with a mean of 21.5 and a maximum value of 95.0 and this is similar to study who reported 93% increased CRP in 28% adult female (Chen et al., 2021). Elevated CRP is also a prognostic value in COVID-19 diagnosis and shows underlying disease or organ injury. Elevated LDH in both male and females with maximum value of 611 in females. This is similar to a studies that reported on clinical and biochemical indexes from 2019-nCoV infected patients to viral loads and lung injury reported that the most common laboratory abnormalities was elevated C-reactive protein (CRP) ,elevated lactate dehydrogenase (LDH) in the 12 cases (Liu et al., 2020; Khalid et al., 2021; Xu et al., 2020).

Coagulation parameter, D-dimer, was markedly high with a maximum value of 7.7 and 35.5 respectively in females and males respectively. Comparing the % of patients tested, male patients had a marked increase as high as 10.9 this is similar to a study that reported that d-dimer may be indicative of worse prognosis in COVID-19 detection (Pourbagheri-sigaroodi, 2020). A similar study reported 32.8% elevated D-dimer in 49% female patients (Cao et al., 2021). In association with COVID-19 and organ impairment, some studies Goudouris (2021); Ghoda & Ghoda (2020); Assiri et al. (2013) reported that, higher levels of CRP, D-dimer, Creatine kinase (CK), urea, and creatinine in addition to some coagulation cascades [procalcitonin, lactic dehydrogenesis (DHL), prothrombin time, activated partial thromboplastin time are associated with a worse prognosis, more severe disease, and thromboembolic complications, including myocardial damage as seen in the study.

In a retrospective analysis of laboratory testing in severe or acute COVID-19 patients (Li et al., 2020; Ghoda & Ghoda, 2020; Lopes-Pacheco et al., 2021), the enzyme alanine aminotransferase (ALT) was utilized as a marker for liver damage (Zghal et al., 2022); readings over the upper limit of the reference ranges indicated both liver and cardiac damage (Hachim et al., 2021; Hachim et al., 2020; Zghal et al., 2022). This affirms the diagnosis that laboratory markers predict the level of damage or injury of some organs as observed in the study.

Conclusion

The most affected organs in our study were the kidney, lungs, and the liver respectively as evidenced per the list of comorbidities recorded. Despite the small sample size, the results obtained demonstrate the importance of laboratory findings in aiding in the management of COVID-19 patients admitted at the isolation Centre of the Korle-Bu Teaching Hospital.

References

1. World Health Organization. (2020). Covid-19 Situation Report. *World Health Organization, 31*(2), 61–66. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200220-sitrep-31-covid-19.pdf
2. Karimi, F., Vaezi, A. A., Qorbani, M., Moghadasi, F., Gelsfid, S. H., Maghoul, A., Mahmoodi, N., Eskandari, Z., Gholami, H., Mokhames, Z., & Saleh, M. (2021). Clinical and laboratory findings in COVID-19 adult hospitalized patients from Alborz province / Iran : comparison of rRT-PCR positive and negative. *BMC Infect Dis, 21*(1), 1–8. DOI: https://doi.org/10.1186/s12879-021-05948-5
3. Agormedah, E. K., Adu Henaku, E., Ayite, D. M. K., & Apori Ansah, E. (2020). Online Learning in Higher Education during COVID-19 Pandemic: A case of Ghana. *Journal of Educational Technology and Online Learning, 3*(3), 183–210. DOI: https://doi.org/10.31681/jetol.726441
4. Mason, R. J. (2020). Pathogenesis of COVID-19 from a cell biology perspective. *European Respiratory Journal, 55*(4), 9–11. DOI: https://doi.org/10.1183/13993003.00607-2020
5. Jin, M., Lu, Z., Zhang, X., Wang, Y., Wang, J., Cai, Y., Tian, K., Xiong, Z., Zhong, Q., Ran, X., Yang, C., Zeng, X., Wang, L., Li, Y., Zhang, S., Dong, T., Yue, X., Li, H., Liu, B., … Wang, Z. (2021). Clinical characteristics and risk factors of fatal patients with COVID-19: a retrospective cohort study in Wuhan, China. *BMC Infectious Diseases, 21*(1), 1–13. DOI: https://doi.org/10.1186/s12879-021-06585-8
6. Wu, Z., & McGoogan, J. M. (2020). Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases from the Chinese Center for Disease Control and Prevention. *JAMA - Journal of the American Medical Association, 323*(13), 1239–1242. DOI: https://doi.org/10.1001/jama.2020.2648
7. Cao, C., He, L., Ma, J., Chen, M., Li, Y., Jiang, Q., Wu, S., Yu, L., Huang, W., Qian, G., Zhu, C., Chu, J., & Chen, X. (2021). Clinical features and predictors for patients with severe SARS-CoV-2 pneumonia at the start of the pandemic: a retrospective multicenter cohort study. *BMC Infectious Diseases, 21*(1), 1–7. DOI: https://doi.org/10.1186/s12879-021-06335-w
8. Li, Y., Hu, Y., Yu, J., & Ma, T. (2020). Retrospective analysis of laboratory testing in 54 patients with severe- or critical-type 2019 novel coronavirus pneumonia. *Laboratory Investigation*, 100, 794–800. DOI: https://doi.org/10.1038/s41374-020-0431-6
9. Liu, Y., Yang, Y., Zhang, C., Huang, F., Wang, F., Yuan, J., Wang, Z., Li, J., Li, J., Feng, C., Zhang, Z., Wang, L., Peng, L., Chen, L., Qin, Y., Zhao, D., Tan, S., Yin, L., Xu, J., … Liu, L. (2020). Clinical and biochemical indexes from 2019-nCoV infected patients linked to viral loads and lung injury. *Science China Life Sciences, 63*(3), 364–374. DOI: https://doi.org/10.1007/s11427-020-1643-8
10. Ofei-palm, C. N. K., Ekpale, P., Gulbi, G., Gyekye, E. P., Akanglah, M., Safo, A. O., Akrofi-addo, N. P., Ahonon, Y., Amoo, P. K., Koduah, A., & Ankrah, D. (2022). Analysis of Hospital Pharmacists ' Interventions in a Covid -19 Isolation Centre of a Tertiary Hospital in Ghana. *Texila International Journal of Public Health, 10*(2), 1–11. DOI: https://doi.org/10.21522/TIJPH.2013.10.02.Art005
11. Chen, L., Liu, H. G., Liu, W., Liu, J., Liu, K., Shang, J., Deng, Y., & Wei, S. (2020). [Analysis of clinical features of 29 patients with 2019 novel coronavirus pneumonia]. In Zhonghua jie he he hu xi za zhi = Zhonghua jiehe he huxi zazhi = *Chinese journal of tuberculosis and respiratory diseases, 43*(3), 203–208. DOI: https://doi.org/10.3760/cma.j.issn.1001-0939.2020.03.013
12. Meng, Z., Guo, S., Zhou, Y., Li, M., Wang, M., & Ying, B. (2021). Applications of laboratory findings in the prevention, diagnosis, treatment, and monitoring of COVID-19. *Signal Transduction and Targeted Therapy, 6*(1), 1–26. DOI: https://doi.org/10.1038/s41392-021-00731-z
13. Goudouris, E. S. (2021). Laboratory diagnosis of COVID-19. *Jornal de Pediatria, 97*(1), 7–12. DOI: https://doi.org/10.1016/j.jped.2020.08.001
14. Statsenko, Y., Al Zahmi, F., Habuza, T., Gorkom, K. N. Van, & Zaki, N. (2021). Prediction of COVID-19 severity using laboratory findings on admission: Informative values, thresholds, ML model performance. *BMJ Open, 11*(2). DOI: https://doi.org/10.1136/bmjopen-2020-044500
15. Chen, M., Zhu, B., Chen, D., Hu, X., Xu, X., Shen, W., Hu, C., & Li, J. (2021). Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information. *Endocrine Practice, 27*(1), 834e841
16. Khalid, M., Awan, S., Jatoi, N. N., Jatoi, H. N., Yasmin, F., Ochani, R. K., Batra, S., Malik, F., Ahmed, J., Chawla, S., Mustafa, A., Lak, H. M., & Surani, S. (2021). Cardiac manifestations of the coronavirus disease-19: A review of path1ogenesis, clinical manifestations, diagnosis, and treatment. *Pan African Medical Journal, 39*. DOI: https://doi.org/10.11604/pamj.2021.39.173.27802
17. Xu, G., Yang, Y., Du, Y., Peng, F., Hu, P., Wang, R., Yin, M., Li, T., Tu, L., Sun, J., Jiang, T., & Chang, C. (2020). Clinical Pathway for Early Diagnosis of COVID-19: Updates from Experience to Evidence-Based Practice. *Clinical Reviews in Allergy and Immunology, 59*(1), 89–100. DOI: https://doi.org/10.1007/s12016-020-08792-8

18. Pourbagheri-sigaroodi, A. (2020). Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect, the company ' s public news and information . January.
19. Ghoda, A., & Ghoda, M. (2020). Liver Injury in COVID-19 Infection: A Systematic Review. *Cureus, 12*(7). DOI: https://doi.org/10.7759/cureus.9487
20. Assiri, A., Al-Tawfiq, J. A., Al-Rabeeah, A. A., Al-Rabiah, F. A., Al-Hajjar, S., Al-Barrak, A., Flemban, H., Al-Nassir, W. N., Balkhy, H. H., Al-Hakeem, R. F., Makhdoom, H. Q., Zumla, A. I., & Memish, Z. A. (2013). Epidemiological, demographic, and clinical characteristics of 47 cases of Middle East respiratory syndrome coronavirus disease from Saudi Arabia: A descriptive study. *The Lancet Infectious Diseases, 13*(9), 752–761. DOI: https://doi.org/10.1016/s1473-3099(13)70204-4
21. Lopes-Pacheco, M., Silva, P. L., Cruz, F. F., Battaglini, D., Robba, C., Pelosi, P., Morales, M. M., Caruso Neves, C., & Rocco, P. R. M. (2021). Pathogenesis of Multiple Organ Injury in COVID-19 and Potential Therapeutic Strategies. *Frontiers in Physiology*, 12, 1–23. DOI: https://doi.org/10.3389/fphys.2021.593223
22. Zghal, M., Bouhamed, M., Mellouli, M., Triki, M., Kallel, R., Ayedi, L., Boudawara, T. S., & Makni, S. (2022). Liver injury in COVID-19: pathological findings. *Pan African Medical Journal*, 41. DOI: https://doi.org/10.11604/pamj.2022.41.56.31114
23. Hachim, I. Y., Hachim, M. Y., Naeem, K. Bin, Hannawi, H., Al Salmi, I., Al-Zakwani, I., & Hannawi, S. (2021). Kidney Dysfunction among COVID-19 Patients in the United Arab Emirates. *Oman Medical Journal, 36*(1), e221. DOI: https://doi.org/10.5001/omj.2020.92
24. Hachim, M. Y., Hachim, I. Y., Naeem, K. Bin, Hannawi, H., Salmi, I. Al, & Hannawi, S. (2020). D-dimer, Troponin, and Urea Level at Presentation With COVID-19 can Predict ICU Admission: A Single Centered Study. *Frontiers in Medicine*, 7, 1–11. DOI: https://doi.org/10.3389/fmed.2020.585003
25. Zghal, M., Bouhamed, M., Mellouli, M., Triki, M., Kallel, R., Ayedi, L., Boudawara, T. S., & Makni, S. (2022). Liver injury in COVID-19: pathological findings. *Pan African Medical Journal,* 41. DOI: https://doi.org/10.11604/pamj.2022.41.56.31114