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Research article

Evaluation of biochemical and hematological parameters and their correlation with the age and gender among COVID-19 patients in Chattogram

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A B S T R A C T

COVID-19, caused by the SARS-CoV-2 virus, has led to a global health crisis. Age and gender are known to influence disease severity and immune response in COVID-19, but data on their effects on routine blood markers remains underexplored, especially in Bangladesh. This study aimed to investigate how blood parameters (ESR, total and differential WBC counts, ferritin, D-dimer, ALT) differ by age and gender in Bangladeshi COVID-19 patients. This cross-sectional study included 351 qRT-PCR–confirmed COVID-19 patients from Chattogram, Bangladesh. Blood samples were analyzed for key hematological and biochemical parameters. All participants were informed about the study, and ethical guidelines were followed throughout. The average age of patients was 56.72 ± 0.89 years, with the majority aged between 50–64 years. All measured blood markers were elevated compared to standard reference ranges. Men had significantly higher ESR, total and differential WBC counts, and ferritin than Women ($p<0.05$). Patients aged ≥65 years showed significantly higher ESR, D-dimer, and ALT levels than younger patients. COVID-19 patients exhibit marked changes in routine blood tests, with higher inflammatory markers (ESR, Ferritin) and enzymes (ALT, D-dimer) in men and older patients. These results highlight the importance of considering age and gender in laboratory assessments. Clinically, these routine markers can aid risk stratification and monitoring, enabling clinicians to identify high-risk cases and tailor patient management accordingly.

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1. INTRODUCTION

SARS-Cov-2 infection, also known as COVID-19, first emerged in December 2019 and rapidly became a global health concern (Lone and Ahmad, 2020; Yuan et al., 2020). This infection, one of the most minacious affairs to the people around the world in recent times; is caused by a member of coronavirus family. In Bangladesh, the first case was confirmed on 8 March 2020. SARS-CoV-2, a member of the Beta coronavirus genus, is notable for its high transmissibility and association with significant morbidity and mortality (Saha et al., 2021). Clinical outcomes of COVID-19 vary widely, ranging from asymptomatic cases to severe respiratory failure and death. Serious clinical consequences, especially in the aged people with co-morbidities, such as diabetes, obesity, cancer, patients of respiratory system, cardiac and cerebrovascular diseases are likely to be the victims of COVID-19 (Bloomgarden, 2020; Chen et al., 2019; Zhou et al., 2020). Identifying reliable clinical and laboratory parameters to stratify disease severity is critical for effective patient management. In this context, hematological and biochemical biomarkers have emerged as important tools for understanding the progression and prognosis of COVID-19 and guiding patient management (Huang et al., 2019). Biomarkers such as C-reactive protein (CRP), D-dimer, lactate dehydrogenase (LDH), serum ferritin, erythrocyte sedimentation rate (ESR), alanine aminotransferase (ALT), serum creatinine, and total white blood cell (WBC) count have been reported to reflect the host's inflammatory and immune responses (Tang et al., 2020).

Elevated levels of CRP, LDH, and D-dimer are associated with increased inflammatory burden, coagulopathy, and multi-organ dysfunction (Bekdas et al., 2014; Chowdhury et al., 2021). Likewise, high serum ferritin and ESR indicate hyperinflammation and cytokine storm, which are hallmark features in critically ill COVID-19 patients (Mehta et al., 2020; Gul et al., 2020). Raised ALT and creatinine levels suggest possible hepatic and renal impairments, particularly in those with severe illness (Zhang et al., 2020). Emerging evidence suggests that these biomarkers may exhibit sex-specific variations, potentially influencing disease severity and outcomes (Jin et al., 2020). Recent studies have highlighted the influence of demographic variables such as sex and age on COVID-19 outcomes. Male patients are more likely to exhibit higher levels of inflammatory markers such as D-dimer and ferritin, and face greater risks of severe disease progression, intensive care unit (ICU) admission, and mortality (Williamson et al., 2020). Differences in immune regulation, hormonal influences, and lifestyle-related factors may underlie these disparities. Similarly, older patients consistently show worse clinical profiles and biomarker elevations, underscoring the role of age as a strong predictor of severity (Tan et al., 2020).

Given these associations, hematological and biochemical indicators can provide a critical window into the pathophysiological status of COVID-19 patients. The present study was designed to assess the variations in hematological and biochemical markers among COVID-19 patients, with a specific focus on gender- and age-related differences. The findings of this study will contribute to the broader understanding of COVID-19 pathogenesis and support the development of sex- and age-specific clinical management strategies.

2. MATERIALS AND METHODS

Study population and ethics

This cross-sectional observational study screened 351 COVID-19 patients for hematological abnormalities from the Surgiscope Hospital PVT Ltd., Chittagong Unit 1, Chattogram, Bangladesh, from April 2020 to September 2021. The sample size was determined based on the expected prevalence of hematological abnormalities in COVID-19 patients, with a 95% confidence level and a 5% margin of error. Sampling involved the inclusion criteria: (i) COVID-19 patients >15 years of age, (ii) COVID-19 cases verified by quantitative reverse transcriptase polymerase chain reaction (qRT-PCR), and (iii) Complete data available for the case record form; and the exclusion criteria: (i) Patients <15 years of age, (ii) COVID-19 cases that are not verified by qRT-PCR, (iii) pregnant women and those who are taking medicine for reducing lymphocyte, leukocytes, or white blood cells count, (iv) patients previously diagnosed

with any hematological disorders, (v) patients with bronchitis or pneumonia or acute and chronic eosinophilic pneumonia, and (vi) COVID-19 positive case with congestive heart failure (CHF). This study was carried out under the ethical permission granted for COVID-19 research by the ethical review committee (ERC) of Chattogram Medical College. Each subject was informed about the study and written informed consent was obtained under a protocol endorsed by the ERC. All data were anonymized to protect patient confidentiality.

Sample collection and analysis

Nasopharyngeal swab, oropharyngeal swab, anterior nasal swab, mid-turbinate, and sputum specimens were collected from patients who were suspected to have COVID-19 by the health care providers. Specimens from swabs were placed immediately after collection into a sterile tube containing 2-3 mL of viral transport medium (VTM). Qualitative detection of SARS-CoV-2 was done by using Sansure Novel Coronavirus (2019-nCoV) Nucleic Acid Detection kit (Sansure Biotech, China) and Quant Studio™ 5 Real-Time PCR System (Applied Biosystems, Thermo Fisher Scientific, USA) and the result was analyzed according to the manufacturer protocol. Overnight fasting blood sample of 5 mL was collected from each patient for serum analysis, hematological evaluation and D-dimer test. Appropriate blood collection vials were used for each test. The blood samples were studied by using the Medonic (BOULe) auto analyzer. The results of blood analysis were studied and approved by a pathologist.

Statistical analysis

Hematological parameters are presented as the mean ± standard deviation (mean ± SD).
Changes in parameters between male and female COVID-19 patients were compared using independent sample t-tests. The correlations in the changes of different blood parameters among different patient age groups were assessed by using ANOVA single factor and independent sample t-test. Microsoft Excel v2021 LTSC was used for data editing, sorting, coding, classification, and tabulation. IBM SPSS software (version 25.0) was also applied for all statistical analyses. Statistical variations or associations with a p-value <0.05 was considered significant.

3. RESULTS

General and clinical information

A total of 351 confirmed COVID-19 patients were included in the study, comprising 192 males (54.70%) and 159 females (45.21%), with a mean age of 56.72 ± 0.89 years (range: 16–95 years). The detailed clinical and laboratory findings are summarized in Table 1. Hematological analysis revealed elevated total white blood cell counts, with a predominance of neutrophils (neutrophilia) and a reduction in lymphocyte percentages (lymphopenia), which are characteristic of systemic viral infections.

Inflammatory biomarkers demonstrated significant elevations, particularly ESR, CRP, D-dimer, and serum ferritin. Notably, D-dimer levels were up to 25-fold higher than the upper reference limit, and CRP levels increased as much as 31-fold, indicating pronounced inflammatory and prothrombotic states. Serum ferritin levels were also markedly elevated, consistent with cytokine-mediated hyper-ferritinemia. Biochemical assessments revealed increased ALT, with values reaching nearly five times the normal upper limit, suggesting hepatic involvement in a subset of patients. Additionally, elevated LDH and serum creatinine levels were observed, reflecting potential tissue damage and renal dysfunction in some cases. These findings underscore a pattern of hematological and biochemical disturbances consistent with the systemic inflammatory response observed in moderate to severe COVID-19 cases.

Table 1: Summary of demographic, clinical, and laboratory parameters of the study population (n=351).

Parameters	Number of patients	Mean± SD	Range	Reference value
Male (n)	192			
Female (n)	159			
Age (in years)	351	56.72±0.89	16-95	--
ESR (mm in 1st hour)	351	55±1.55	4-140	F: 0-15; M: 0-10
TC of WBC (cells/µl)	351	11448.66±280.85	1300-35000	4000 – 11000
DC of WBC (cells/µl) (N)	351	77.96±0.59	010-93	40 - 75%
DC of WBC (cells/µl) (L)	351	18.74±0.59	4--82	20 – 45%
DC of WBC (cells/µl) (M)	351	2.63±0.06	1--14	02 – 10%
DC of WBC (cells/µl) (E)	351	1.85±0.08	1--19	01 – 06%
CRP (mg/L)	351	76.4±4.3	0.6-345	<3
D-dimer (µgm/mL)	351	2.46±0.17	0.1-18.7	<0.5
S ferritin (ng/mL)	351	492.80±26.65	12.8-1968	M: 13-370, F: 9-253
S ALT (u/L)	351	106.66±8.34	18-1241	M: 16-63, F: 14-59
S Creatinine (mg/dL)	351	1.43±0.10	0.15-2.5	M: 0.7-1.3, F: 0.5-1.2
LDH (U/L)	351	394.02±0.20	102-5381	140-280

Data are presented as mean ± standard deviation (SD) (except were indicated otherwise). Reference values indicate normal ranges and are stratified by sex (M = male, F = female) where applicable. The reference values were set according to the test protocols. Here, ALT=Alanine aminotransferase; CRP=C-reactive protein; DC=Differential count; ESR=Erythrocyte sedimentation rate; LDH=Lactate dehydrogenase; TC=Total count; WBC=White blood cell count.

Demographic information

In this study, males and females were categorized into several groups on the basis of age and values of different biomarkers were twigged in between and within two sexes. The age groups are: 15-19 years, 20-34 years, 35-49 years, 50-64 years, 65-79 years and ≥80 years (Figure 1). In our study, highest number of patients were in the two age-groups: 136 in 50-64 years old and 94 in 65-79 years old. COVID-19 infection frequency was found higher in the aged population rather than the younger. Similar result was observed when the study population was sub-grouped in male and female (Figure 2).

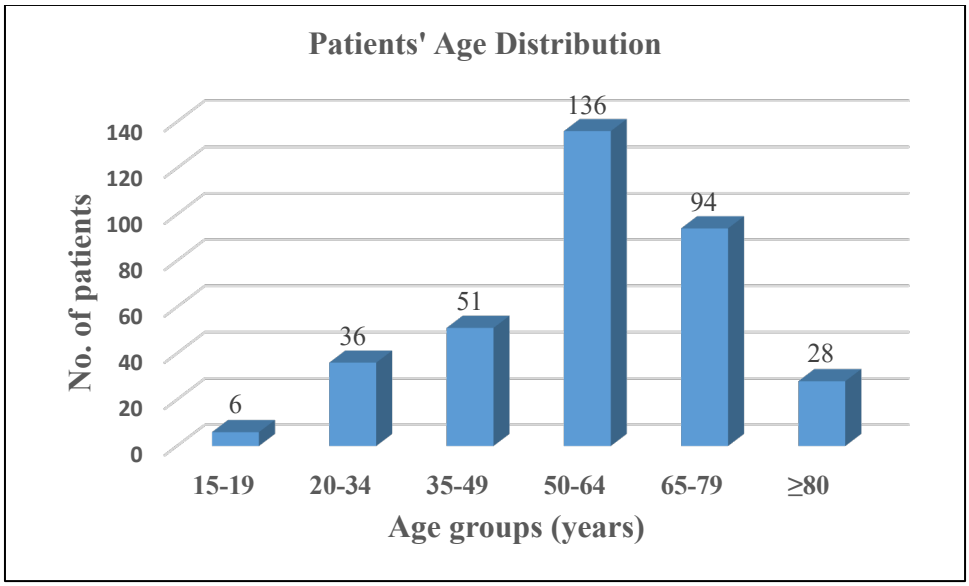

Figure 1. Age-wise distribution of COVID-19 patients in the study population (n = 351). This represents the distribution of COVID-19-positive patients across six age groups. The majority of patients belonged to the 50–64 years age group (n=136), accounting for 38.7% of the total cohort. This was followed by the 65–79 years group (n=94, 26.8%) and the 35–49 years group (n=51, 14.5%). The lowest representation was in the 15–19 years group (n=6). The distribution indicates a higher incidence of COVID-19 among middle-aged and elderly individuals in this study.

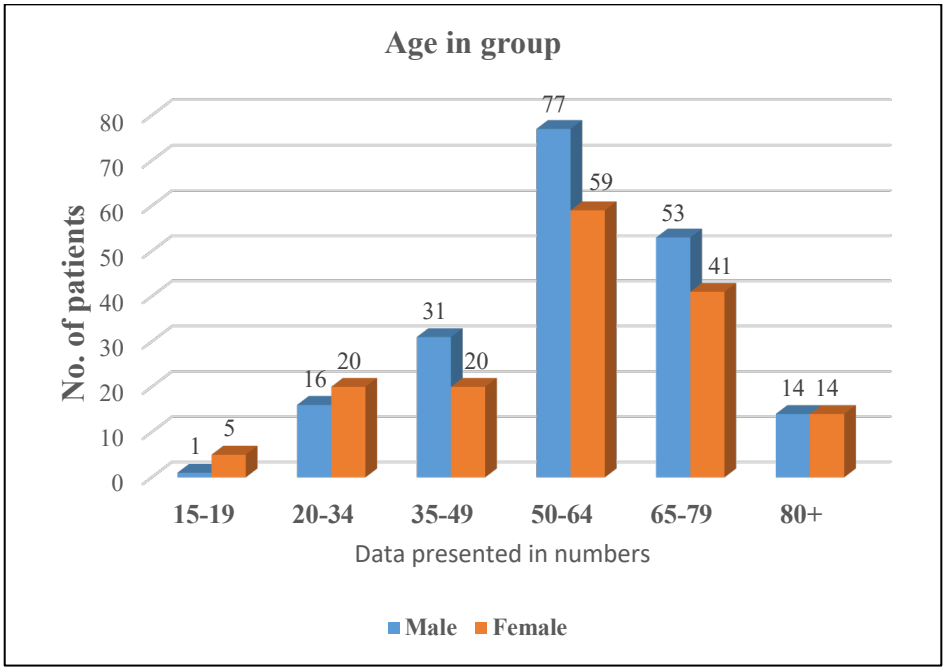

Figure 2. Distribution of COVID-19 patients by age group and sex (n=351). This shows the age-wise distribution of male and female COVID-19 patients. The highest number of cases for both sexes was in the 50–64 years age group, with 77 males and 59 females. The 65–79 years group followed, with 53 males and 41 females. This distribution indicates that middle-aged and elderly individuals, particularly males, were more frequently affected in the studied population.

Table 2. Comparison of hematological and biochemical parameters between male and female COVID-19 patients.

Parameter	Male	Female	*P* value
No. of patients	192 (54.70%)	159 (45.30%)	--
Age (in years)	57.65±1.12	55.60±1.41	0.258
ESR (mm in 1st hour)	50.63±2.13	61.74±2.17	**0.0003**
TC of WBC (cells/µl)	11939.58±399.18	10855.85±386.06	**0.05**
DC of WBC (cells/µl) (N)	77.761±0.84	78.96±0.77	0.114
DC of WBC (cells/µl) (L)	19.11±0.84	18.28±0.81	0.47
DC of WBC (cells/µl) (M)	2.78±0.09	2.45±0.06	**0.004**
DC of WBC (cells/µl) (E)	1.85±0.06	1.86±0.15	0.938
CRP (mg/L)	74.72±5.65	78.52±6.65	0.663
D-dimer (µgm/mL)	2.46±0.21	2.46±0.26	0.994
S ferritin (ng/mL)	547.52±34.67	426.73±40.85	**0.025**
S ALT (u/L)	109.62±13.31	103.07±9.02	0.684
S Creatinine (mg/dL)	1.52±0.11	1.31±0.09	0.158
LDH (U/L)	397.47±19.13	389.84±39.29	0.862

Here, the values are shown as mean ± SE (except indicated otherwise) and analyzed by Student's t-test. The p values in 'bold' are significant (significance level is $p<0.05$). Statistically significant differences were observed in ESR, monocyte count, and serum ferritin levels ($p<0.05$).

Evaluation of biochemical and hematological parameters according to age and gender

Evaluation of biochemical and hematological assessment depending on age and gender showed significant differences in elevated ESR level ($p=0.0003$), TC of WBC level ($p=0.05$), monocyte level ($p=0.004$) and serum ferritin level ($p=0.025$) in the Chi-squared test and t-test. No momentous difference was found in the other parameters between men and women.

Evaluation of biochemical and hematological parameters according to Age-groups

Variations were found in the biochemical and hematological parameters among the different age-group patients. For ESR, both in the male and female patients, this variation was found significant ($p<0.05$). In case of age-group 35-49 years, ESR value was found significantly higher in female (ESR= 62, $p<0.05$) whereas among the older adults (>80 years) this value was found significantly higher in male patients. Serum ferritin value was found significantly higher in 35-49 years old male patient group.

Total Count of WBC was found significantly higher in younger adult female ($p<0.05$) and among the female patients this value showed significant variation in different age-groups. On the other hand, differential count of WBC value for monocyte, neutrophil and lymphocyte cells showed no significant difference in male and female and also in different age-group. CRP test value showed no significant difference according to age distribution, but it was found (86.4±16.13 mg/L) significantly higher ($p<0.05$) in the older adult (>80) male study patients. D-dimer value was found (5.34±1.04 µgm/mL) significantly higher ($p<0.05$) in the older adult (>80) male study patients. This parameter showed significant variation among the different age-group in the male study patients.

Serum ALT value was found (124.93±30.58 u/L) significantly higher ($p<0.05$) in the older adult (>80) male study patients. But for Serum ALT, Serum Creatinine and LDH no significant difference was found among the study patients.

Table 3: Age- and Sex-stratified distribution of hematological and biochemical parameters among the study patients (n=351).

		Age groups (years)					
Parameters	**Gender**	**20-34**	**35-49**	**50-64**	**65-79**	**80+**	***p* value**
ESR	Male	43.94±7.69	42.81±5.73	46.83±3.14	58.26±4.05	66.71±6.24	0.014
	Female	54.05±4.92	62.8±5.62	70.03±3.72	60.39±4.27	48.64±5.36	0.016
	p value	0.278	0.016	5.25	0.719	0.049	
S ferritin	Male	539.01±135.23	558.367±5.57	568.01±56.26	544.73±65.10	445.78±82.79	0.966
	Female	392.1±118.096	261.08±89.60	553.19±80.69	400.49±59.65	392.82±132.04	0.123
	p value	0.419	0.025	0.881	0.106	0.738	
TC of WBC (cells/µl)	Male	13312.5±1908.7	11729.03±922.79	11802.59±621.61	11394.34±640.88	12614.28±1685.16	0.118
	Female	8705±8688.89	9820±926.86	11845.4±717.66	11843.9±581.4	8778.57±570.46	0.035
	p value	0.04	0.22	0.964	0.965	0.074	
CRP (mg/L)	Male	60.31±17.03	55.58±19.39	69.92±20.09	91.31±19.66	86.4±16.13	0.105
	Female	83.59±17.98	60.59±16.05	93.79±12.17	80.28±13.29	38.79±9.96	0.234
	p value	0.354	0.815	0.119	0.521	0.026	
D-dimer (µgm/mL)	Male	1.465±0.44	1.47±0.33	2.05±0.31	3.20±0.46	5.34±1.04	0.0001
	Female	2.81±0.78	1.53±0.57	2.85±0.52	2.18±0.39	2.58±0.65	0.706
	p value	0.142	0.935	0.192	0.092	0.035	
S ALT (u/L)	Male	222.41±135.61	77.91±11.23	100.29±9.60	105.17±19.13	124.93±30.58	0.196
	Female	117.53±27.23	98.3±17.77	119.79±18.95	95.72±14.19	54.14±8.7	0.424
	p value	0.459	0.339	0.361	0.692	0.042	
S Creatinine (mg/dL)	Male	1.07±0.19	1.50±0.39	1.56±0.44	1.57±0.34	1.70±0.38	0.873
	Female	1.52±0.34	1.12±0.17	1.37±0.17	1.34±0.15	1.28±0.34	0.623
	p value	0.265	0.248	0.482	0.328	0.431	
LDH (U/L)	Male	426.25±86.39	365.32±64.09	413.27±77.37	398.50±67.39	334.86±41.06	0.854
	Female	317.4±95.93	233.66±63.89	483.24±316.80	445.36±177.78	238.07±68.14	0.198
	p value	0.258	0.017	0.477	0.512	0.106	
	Male	75.94±3.01	77.45±1.65	77.36±1.58	76.51±1.56	78.64±2.05	0.986
	Female	77.05±2.35	82.65±1.84	77.15±1.46	80.15±1.24	79.5±2.15	0.238

DC of WBC (cells/µl) (N)	p value	0.857	0.04	0.893	0.922	0.775	
DC of WBC (cells/µl) (L)	Male	18.88±2.54	17.55±2.10	18.44±1.23	21.47±2.11	17.93±1.57	0.659
	Female	19.85±2.44	14.85±2.32	18.85±1.36	18.66±1.36	18.71±4.14	0.606
	p value	0.784	0.336	0.825	0.289	0.791	
DC of WBC (cells/µl) (M)	Male	3±0.22	2.61±0.17	2.71±0.12	2.88±0.24	2.93±0.48	0.854
	Female	2.3±0.18	2.5±0.14	2.46±0.11	2.49±0.14	2.50±0.17	0.928
	p value	0.026	0.616	0.126	0.152	0.427	
DC of WBC (cells/µl) (E)	Male	1.94±0.06	2.13±0.29	1.78±0.08	1.83±0.08	1.64±0.13	0.371
	Female	1.6±0.17	1.55±0.11	1.75±0.16	2.44±0.52	1.64±0.13	0.37
	p value	0.073	0.072	0.853	0.254	1	

Here, the values are shown as mean±SE (except indicated otherwise). The correlation between the gender and biochemical parameters were analyzed by Student's t test. The correlation between the gender and biochemical parameters were analyzed by Anova. The p values in 'bold' are significant (significance level is $p<0.05$). 15-19 years old age-group was excluded from the calculation due to small amount of data.

4. DISCUSSION

COVID-19, caused by SARS-CoV-2, has emerged as a multifaceted systemic infection with implications beyond the respiratory tract, impacting hematologic and biochemical parameters (Zhang et al., 2020; Jin et al., 2020). The current study aimed to explore these laboratory abnormalities in qRT-PCR-confirmed COVID-19 patients in Chattogram, Bangladesh, with a specific focus on age and sex-based variations.

Elevated inflammatory markers such as ESR, CRP, and serum ferritin were prominent across the population, consistent with findings from previous studies (Deng et al., 2019; Ali et al., 2022; Ghazanfari et al., 2021; Wang et al., 2019). However, the higher ESR and ferritin levels observed in female patients diverge from several international reports, which typically associate more severe inflammatory responses with male sex (Peckham et al., 2020; Scully et al., 2020; Statsenko et al., 2021; Alkhouli et al., 2020; Sha et al., 2021; Liu et al., 2020). This sex-based discrepancy may reflect underlying genetic, hormonal, or population-specific immune response differences. The significance of these elevated markers in females warrants further investigation, particularly in terms of prognostic relevance. Conversely, male patients exhibited a trend toward higher D-dimer levels, especially in older age groups. This aligns with studies linking male sex and advanced age to increased thromboembolic risk and poorer clinical outcomes (Schlagenhauf et al., 2010; Zhao et al., 2020). Elevated D-dimer has been identified as a predictor of disease severity and mortality, likely due to hypercoagulability induced by endothelial dysfunction and cytokine storm (Tang et al., 2020).

Age appeared to influence several laboratory parameters. Age-wise stratification revealed that patients over 80 years had significantly elevated ESR and D-dimer levels, supporting the hypothesis that aging exacerbates systemic inflammation and coagulopathy (Liu et al., 2020; Schlagenhauf et al., 2010). Moreover, notable biochemical deviations in middle-aged groups (e.g., LDH and ALT in the 35–49 years group) indicate that hepatic and cellular stress is not confined to the elderly. These findings underscore the heterogeneous nature of COVID-19's systemic impact across age groups.

The novel aspect of our study lies in its granular analysis of both age- and sex-specific trends in hematologic and biochemical markers,

specifically in a South Asian population, which remains underrepresented in global COVID-19 datasets. Most previous studies generalize findings without age or sex stratification or are focused on Western or East Asian population. The elevated CRP and ferritin levels point toward an ongoing systemic inflammatory response, while raised ALT and LDH suggest potential liver and cellular injury, consistent with hepatocellular involvement described in literature (Zhang et al., 2020; Zhao et al., 2020). The diagnostic utility of these markers in predicting disease severity, organ dysfunction, and prognosis is further reinforced by this study. Importantly, this study supports prior assertions that hematological and biochemical parameters can serve as useful biomarkers for COVID-19 severity. However, it also highlights the need to interpret these markers in the context of patient age and sex, as both factors significantly modulate laboratory findings. Understanding how these markers vary by age and sex can help clinicians tailor prognostic assessments and therapeutic strategies more effectively. For instance, elevated ferritin and ESR in females should not be underestimated as benign, while D-dimer monitoring may be especially critical in older male patients. Future research should explore longitudinal changes in these markers and investigate correlations with clinical outcomes such as ICU admission, duration of hospitalization, and mortality. Moreover, multicenter studies including diverse populations would help validate the generalizability of these findings.

5. CONCLUSION

This study underscores the utility of hematological and biochemical markers particularly CRP, D-dimer, ESR, serum ferritin, ALT, and LDH—in evaluating the systemic impact of COVID-19. Significant variations by age and sex suggest these markers should be interpreted in a demographic context. Elevated ferritin and ESR in females and higher D-dimer levels in elderly males may reflect distinct inflammatory and coagulopathic responses. These findings emphasize the importance of individualized assessment and support the integration of routine laboratory data into COVID-19 risk stratification and management protocols. Incorporating age and sex considerations into clinical interpretation may enhance the precision of COVID-19 management strategies. Further multicenter studies with larger cohorts are recommended to validate and expand upon these observations.

LIMITATIONS

This study has several limitations that should be acknowledged. First, the relatively small sample size may limit the generalizability of the findings. Second, the absence of detailed clinical data, including information on treatment protocols and patient outcomes, restricts our ability to account for potential confounding factors such as the effects of medications (e.g., corticosteroids or antivirals) on the observed hematological and biochemical parameters. Third, the study lacked a healthy control group, which would have allowed for a more robust comparison and interpretation of laboratory deviations. These limitations highlight the need for larger, multi-center studies incorporating longitudinal follow-up and control populations to validate and expand upon our findings.

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