

Research Article

Hematological Findings in Patients Evaluated for COVID-19 at Private Laboratories in Tlemcen, Algeria: A Retrospective Descriptive Study

Wafaa Lemerini¹, Ilyes Zatla², Assia Tchouar³, Souhila Tchouar⁴, Chahinez Triqui⁵

^{1,3,4}Laboratory of Organic Chemistry, Natural Substances, and Analysis, ⁵Faculty of Natural and Life Sciences, Earth and Universe Sciences, Department of Biology, University of Abou Bekr Belkaid, Tlemcen, Algeria

²PhD in Microbiology, Independent Researcher, Tlemcen, Algeria

DOI: <https://doi.org/10.24321/0019.5138.202675>

I N F O

Corresponding Author:

Ilyes Zatla, Independent Researcher, Tlemcen, Algeria

E-mail Id:

ilyes.zatla@aol.com

Orcid Id:

<https://orcid.org/0000-0003-0476-8765>

How to cite this article:

Lemerini W, Zatla I, Tchouar A, Tchouar S, Triqui C. Hematological Findings in Patients Evaluated for Covid-19 at Private Laboratories in Tlemcen, Algeria: A Retrospective Descriptive Study. J Commun Dis. 2026;58(3):244-250.

Date of Submission: 2025-08-19

Date of Acceptance: 2025-09-23

A B S T R A C T

Background: Complete blood count (CBC) abnormalities have been described in COVID-19, but evidence from private diagnostic laboratories in North Africa remains limited. **Objective:** To describe selected hematological findings and their interrelationships in patients evaluated for COVID-19 in Tlemcen, Algeria.

Methods: This retrospective descriptive study included 50 patient records from private medical biology laboratories between January and March 2024. SARS-CoV-2 testing used PCR and rapid antigen assays on nasopharyngeal swabs. Age, sex, white blood cell (WBC), red blood cell (RBC), and platelet (PLT) counts, and lymphocyte (LYM%) and neutrophil (NEU%) percentages were examined. Analyses comprised descriptive statistics, Pearson correlations, and principal component analysis of earlier (P) and episode-associated (R) measurements.

Results: Mean age was 61.4 ± 14.7 years (range 16–89); 34 participants (68%) were older than 60 years and 33 (66%) were female. Recorded abnormalities included leukocytosis (16%), reduced and elevated lymphocyte percentages (12% each), and leukopenia (10%). Lymphocyte and neutrophil percentages were strongly inversely correlated at both measurement periods (P: $r = -0.968$; R: $r = -0.927$). The first two principal components explained 54.465% of the total variance.

Conclusion: This selected laboratory cohort showed heterogeneous hematological findings. The strong inverse relationship between lymphocyte and neutrophil percentages partly reflects their compositional dependence. Incomplete characterization of sampling times, missing clinical outcomes, and the absence of a control group restrict interpretation to descriptive associations.

Keywords: COVID-19, SARS-CoV-2, Complete Blood Count, Lymphocytes, Neutrophils, Platelets, Algeria, Retrospective Study

Introduction

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), encompasses a broad clinical spectrum, from mild respiratory illness to pneumonia, respiratory failure, and multisystem complications.^{1,2} Host immune responses and inflammatory processes contribute to this heterogeneity and are reflected, in part, in routinely measured hematological parameters.³

Laboratory evaluation contributes to the clinical assessment of patients with COVID-19. Among routinely available tests, the complete blood count (CBC) is inexpensive and can provide information on leukocyte, erythrocyte, and platelet patterns. Reported abnormalities include lymphopenia, neutrophilia, leukocytosis or leukopenia, and thrombocytopenia, with the magnitude and direction of these changes varying according to disease stage, severity, comorbidities, treatment, and study setting.⁴⁻⁸

Several studies have also examined derived inflammatory indices, particularly the neutrophil-to-lymphocyte ratio (NLR), as potential markers of disease severity.⁹⁻¹¹ However, interpretation of differential leukocyte percentages requires caution because lymphocyte and neutrophil percentages are compositional measures whose values are mathematically interdependent. CBC abnormalities should therefore be interpreted alongside clinical findings and, when available, absolute cell counts and other inflammatory markers.

Algerian studies have documented COVID-19 epidemiology, clinical presentations, and hematological findings, including reports from Tlemcen and Oran.^{8,12-14} Private laboratory records offer an additional perspective on patients accessing diagnostic services outside hospital-based research cohorts. However, such records require cautious interpretation because clinical information and the circumstances of testing may be incomplete.

The present study therefore aimed to describe selected hematological parameters in a cohort of patients evaluated for COVID-19 in private laboratories in Tlemcen, Algeria, and to explore correlations and multivariable patterns among earlier and contemporaneous CBC measurements. The study was intended as a descriptive analysis rather than an assessment of diagnostic accuracy, prognosis, or treatment response.

Methods

Study design and setting

This retrospective descriptive study was conducted in private medical biology laboratories in Tlemcen, north-western Algeria, using records collected between January and March 2024. The analysis focused on demographic information, SARS-CoV-2 test results, and selected CBC

variables available in the laboratory records. Because the study was based on a convenience sample from private laboratories, the cohort should not be considered representative of all COVID-19 cases in Tlemcen.

Study population and available variables

The analysis included 50 anonymous patient records containing demographic information, SARS-CoV-2 testing information, and selected CBC measurements. Earlier measurements were coded P and measurements associated with the COVID-19 evaluation were coded R. The precise interval between P and R, the completeness of paired observations, and detailed eligibility criteria were not documented in the available study information. R therefore denotes an episode-associated laboratory measurement rather than a standardized sampling time relative to symptom onset.

The hematological variables were total WBC count, RBC count, PLT count, LYM%, and NEU%. LYM% and NEU% represent proportions of the total leukocyte differential; their values are not absolute cell counts. RBC count was analyzed as a cell count and was not used to diagnose anemia.

SARS-CoV-2 testing

All specimens collected for SARS-CoV-2 testing were nasopharyngeal swabs. Laboratory testing used real-time reverse polymerase chain reaction (RT-PCR) and rapid antigen tests. Serological assays were also used to establish eligibility. The available aggregate study information did not specify the participant-level distribution of PCR and rapid antigen testing or the assay manufacturers.

Hematological classification

Abnormalities were summarized using the categories recorded in the study dataset. Analyzer specifications, measurement units, laboratory reference intervals, and classification thresholds were not available. Frequencies therefore represent recorded classifications rather than abnormalities independently reassessed against standardized reference limits. For the leukocyte differential, the terms reduced or elevated lymphocyte or neutrophil percentage are used to avoid implying an abnormal absolute cell count. Categories were not mutually exclusive.

Statistical analysis

Data were organized in Microsoft Excel 2019 and analyzed in SPSS version 21 (IBM Corp., Armonk, NY, USA). Age was summarized using the mean, standard deviation, and range; categorical variables were summarized as counts and percentages. Each recorded abnormality was expressed as a proportion of the full cohort (N = 50).

Pearson correlation coefficients summarized associations among the 10 P/R hematological variables. Pairwise

sample sizes, missing-data handling, and assessments of distributional assumptions or outliers were not documented. The original analysis used two-sided significance thresholds of $p < 0.05$ and $p < 0.01$ without a reported multiplicity adjustment. The present interpretation emphasizes coefficient magnitude and direction; significance markers are omitted because the effective pairwise denominators cannot be established from the reported matrix.

Principal component analysis (PCA) was used to summarize covariance among the 10 measurements. The first two reported initial eigenvalues and their corresponding percentages of explained variance are presented. Details of preprocessing, component-retention criteria, rotation, and adequacy diagnostics were not documented. The analysis is treated as exploratory, and no inferential claims are based on component separation.

Results

Demographic characteristics

The study included 50 patient records. Participants ranged from 16 to 89 years of age, with a mean age of 61.4 ± 14.7 years. Thirty-four participants (68%) were older than 60 years. Females accounted for 33 cases (66%) and males for 17 cases (34%). These proportions describe the selected laboratory cohort and should not be interpreted as population-level age- or sex-specific risk estimates.

Recorded hematological abnormalities

Leukocytosis was the most frequently recorded abnormality (8/50, 16%). Reduced and elevated lymphocyte percentages were each recorded in 6/50 patients (12%), followed by leukopenia in 5/50 (10%). Low RBC count occurred in 4/50 (8%), and elevated RBC count, thrombocytopenia, and elevated neutrophil percentage each occurred in 3/50 (6%). Reduced neutrophil percentage was recorded in 2/50 (4%) and thrombocytosis in 1/50 (2%) (Table 1). These frequencies do not indicate the proportion of patients with any abnormality because categories can overlap.

Percentages use the full cohort as denominator. Categories may overlap. WBC, white blood cells; RBC, red blood cells;

PLT, platelets; LYM%, lymphocyte percentage; NEU%, neutrophil percentage. Recorded classifications were not independently validated against laboratory reference thresholds.

Correlation analysis

The strongest inverse correlations involved LYM.P and NEU.P ($r = -0.968$) and LYM.R and NEU.R ($r = -0.927$). Positive correlations between earlier and episode-associated measurements were observed for WBC ($r = 0.582$), RBC ($r = 0.476$), PLT ($r = 0.495$), LYM% ($r = 0.478$), and NEU% ($r = 0.510$). WBC.P correlated positively with NEU.P ($r = 0.533$) and negatively with LYM.P ($r = -0.542$); corresponding associations for the episode-associated measurements were $r = 0.492$ and $r = -0.603$, respectively (Table 2 and Figure 1).

These correlations describe covariation among measured variables and do not establish causality or prognostic value. In particular, the very strong inverse correlations between lymphocyte and neutrophil percentages should be interpreted in light of the compositional nature of differential leukocyte percentages.

P, earlier measurement; R, measurement associated with COVID-19 evaluation. LYM and NEU denote percentages. The lower triangle is omitted because the matrix is symmetric. Coefficients are reproduced from the reported analysis; pairwise sample sizes were unavailable.

Principal component analysis

The first two principal components explained 54.465% of total variance. Component 1 accounted for 36.634% and component 2 for 17.831%, with reported initial eigenvalues of 3.663 and 1.783, respectively (Table 3). The remaining variance was distributed across the other components. These results summarize the reported variance structure without establishing distinct biological pathways.

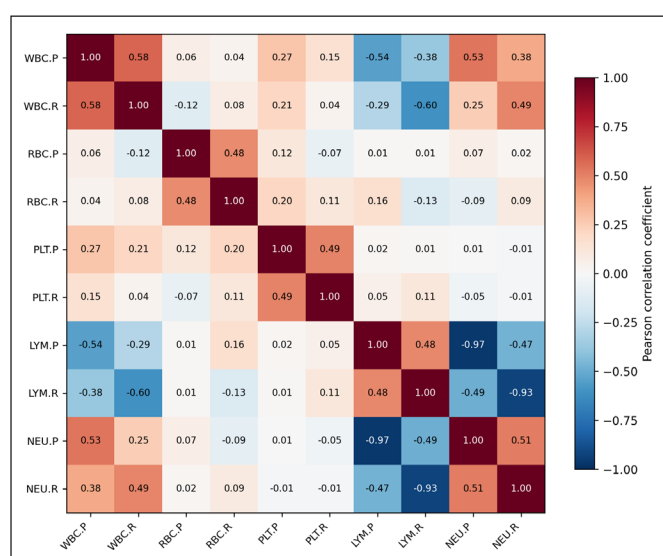
Eigenvalues and percentages are shown at the precision reported in the analysis. The table presents initial eigenvalues only.

Table 1. Recorded hematological abnormalities in the study cohort (N = 50)

Parameter	Recorded abnormality	Patients, n	Percentage
WBC	Leukocytosis	8	16
	Leukopenia	5	10
RBC	Low RBC count	4	8
	Elevated RBC count	3	6
PLT	Thrombocytopenia	3	6
	Thrombocytosis	1	2
LYM%	Reduced lymphocyte percentage	6	12
	Elevated lymphocyte percentage	6	12
NEU%	Elevated neutrophil percentage	3	6
	Reduced neutrophil percentage	2	4

Table 2. Pearson correlations among earlier (P) and episode-associated (R) hematological measurements

Variable	WBC.P	WBC.R	RBC.P	RBC.R	PLT.P	PLT.R	LYM.P	LYM.R	NEU.P	NEU.R
WBC.P	1.000	0.582	0.064	0.037	0.274	0.152	-0.542	-0.382	0.533	0.381
WBC.R	—	1.000	-0.124	0.078	0.206	0.035	-0.292	-0.603	0.249	0.492
RBC.P	—	—	1.000	0.476	0.117	-0.074	0.015	0.015	0.070	0.022
RBC.R	—	—	—	1.000	0.204	0.112	0.157	-0.133	-0.087	0.090
PLT.P	—	—	—	—	1.000	0.495	0.020	0.013	0.006	-0.015
PLT.R	—	—	—	—	—	1.000	0.050	0.113	-0.046	-0.009
LYM.P	—	—	—	—	—	—	1.000	0.478	-0.968	-0.472
LYM.R	—	—	—	—	—	—	—	1.000	-0.490	-0.927
NEU.P	—	—	—	—	—	—	—	—	1.000	0.510
NEU.R	—	—	—	—	—	—	—	—	—	1.000

**Figure 1. Heatmap of the Pearson correlation coefficients in Table 2. Red indicates positive and blue negative correlations. Values are rounded to two decimal places for display. This visualization represents the reported aggregate matrix and does not constitute a new patient-level analysis****Table 3. Initial eigenvalues and explained variance for the first two principal components**

Component	Initial eigenvalue	Variance (%)	Cumulative variance (%)
1	3.663	36.634	36.634
2	1.783	17.831	54.465

Discussion

This retrospective analysis describes selected CBC findings in 50 patients evaluated in private laboratories in Tlemcen. The cohort was predominantly older than 60 years and female, but these distributions reflect the sampled records and do not establish population-level susceptibility. Hematological abnormalities were heterogeneous: leukocytosis was the most common single abnormality (16%), whereas reduced and elevated lymphocyte percentages were each recorded

in 12%, leukopenia in 10%, and thrombocytopenia and elevated neutrophil percentage in 6% each.

The direction and frequency of these changes are broadly compatible with heterogeneous hematological patterns reported in COVID-19.^{5-8,15-17} However, recorded frequencies in this study should not be directly compared with hospital cohorts enriched for severe disease. Low RBC count should not be equated with anemia in the absence of hemoglobin, hematocrit, red-cell indices, and laboratory reference

ranges. Similarly, platelet and leukocyte abnormalities may reflect infection, comorbidity, medication use, intercurrent bacterial infection, or other clinical factors that were not captured in the available dataset.

The correlation analysis showed marked inverse relationships between lymphocyte and neutrophil percentages, both in earlier and COVID-19-episode measurements. Although this pattern is compatible with the commonly described shift toward neutrophil predominance and reduced lymphocyte representation in inflammatory states,⁹⁻¹¹ the magnitude of the correlations must be interpreted cautiously. LYM% and NEU% are components of the same leukocyte differential and are therefore mathematically constrained; a strong negative correlation can arise partly from this compositional structure. Consequently, these correlations should not be presented as independent validation of the NLR or as evidence of disease severity.

Moderate positive correlations between P and R measurements indicate that patients with relatively higher values at one measurement tended to have higher values at the other. These associations do not demonstrate increases or decreases attributable to infection. No paired mean differences or longitudinal clinical outcomes were reported, so the analysis cannot establish a temporal hematological response to SARS-CoV-2.

The first two principal components summarized just over half of the total variance. This offers a concise description of a dataset containing repeated and interrelated hematological variables. However, the absence of documented preprocessing and component-retention methods limits reproducibility, and the modest sample size limits the stability of multivariable interpretations. The PCA does not establish diagnostic discrimination or prognostic performance.

The small convenience sample from private laboratories limits generalizability. Detailed selection criteria were unavailable, including whether abnormal CBC findings influenced record inclusion. Recorded abnormality frequencies therefore cannot be interpreted as population prevalence estimates. There was no non-COVID comparison group. Although all specimens were nasopharyngeal swabs and testing used PCR and rapid antigen assays, participant-level test allocation and assay specifications were unavailable. The timing of testing relative to symptom onset and the timing and completeness of paired CBC measurements were insufficiently characterized.

Clinical severity, symptoms, comorbidities, vaccination status, medications, hospitalization, outcomes, and inflammatory biomarkers were unavailable. Analyzer specifications, units, reference intervals, and abnormality thresholds were not documented, preventing standardized

reassessment. The absence of absolute leukocyte counts limits interpretation of percentage-based changes. Correlation estimates are additionally constrained by unknown pairwise sample sizes, undocumented assumption checks, compositional dependence, and multiple testing. These limitations preclude causal attribution, prognostic claims, and assessment of diagnostic accuracy.

Despite these limitations, the study provides a local descriptive snapshot of CBC variability in a private-laboratory cohort from Tlemcen. Its main value lies in documenting the distribution of routinely measured hematological variables and generating hypotheses for larger, prospectively designed Algerian studies that incorporate standardized virological confirmation, absolute leukocyte counts, NLR, clinical severity, comorbidities, treatment, and longitudinal outcomes.

Conclusion

In this retrospective series of 50 patients evaluated for COVID-19 in private laboratories in Tlemcen, recorded hematological abnormalities were heterogeneous. Leukocytosis was the most frequent abnormality, while lymphocyte and neutrophil percentages showed strong inverse correlations at both measurement periods. The first two principal components explained 54.465% of total variance. These findings describe a selected laboratory cohort and support further investigation using standardized infection definitions, absolute differential counts, and linked clinical outcomes. They do not establish COVID-19-specific changes or clinical predictive value.

Declarations

Acknowledgments

The authors dedicate this article to the memory of Mr. Lemerini Yahia, father of the first author, whose loss during the COVID-19 pandemic motivated the authors' interest in the hematological manifestations of SARS-CoV-2 infection.

Sources of Funding: None

Conflicts of interest: None

Author contributions

Conceptualization, W.L.; methodology, A.T.; validation, I.Z.; formal analysis, A.T. and S.T.; investigation, W.L.; data curation, S.T.; writing—original draft preparation, I.Z.; writing—review and editing, I.Z.; visualization, I.Z.; supervision, C.T. All authors have read and approved the final manuscript.

Ethics and data confidentiality

This retrospective study used anonymous laboratory records. No names, contact details, or other directly identifying patient information were collected. The

laboratory directors authorized data collection. The analysis involved no direct contact with patients, and results are presented in aggregate form.

Data availability

All data generated or analyzed during this study are included in this published article.

References

1. Xie NN, Zhang WC, Chen J, Tian FB, Song JX. Clinical characteristics, diagnosis, and therapeutics of COVID-19: a review. *Curr Med Sci.* 2023;43(6):1066-1074. [Google Scholar] [PubMed]
2. Steiner S, Kratzel A, Barut GT, Lang RM, Aguiar Moreira E, Thomann L, et al. SARS-CoV-2 biology and host interactions. *Nat Rev Microbiol.* 2024;22(4):206-225. [Google Scholar] [PubMed]
3. Brodin P. Immune determinants of COVID-19 disease presentation and severity. *Nat Med.* 2021;27(1):28-33. [Google Scholar] [PubMed]
4. Onuigwe FU, Abdullahi RK, Uchechukwu NJ, et al. Role of haematology laboratory in COVID-19 infections. *Elite J Lab Med.* 2024;2(5):1-12. [Google Scholar]
5. Kumar HA, Shetty A, Kumar MP, Veena CN. Hematological profile of COVID-19 patients in Ramanagar district, Karnataka: a cross-sectional study. *Biomedicine.* 2022;42(3):539-542. [Google Scholar]
6. Debnath S, Mondal S, Biswas MR. Pathophysiologic mechanism of hematological abnormalities in COVID-19 patients and its implication in the prognosis and disease severity: a retrospective study in a tertiary care COVID hospital. *Indian J Public Health Res Dev.* 2023;14(1). [Google Scholar]
7. Singh I, Kotasthane VD, Kotasthane DS. Correlation between lymphopenia and other hematological parameters with duration of hospital stay as a measure of severity in COVID-19: a retrospective study. *Egypt J Intern Med.* 2024;36:17. [Google Scholar]
8. Moueden MA, Benlaldj D, Messaoudi R, Seghier F. Profil hématologique des patients atteints de COVID-19 au niveau du CHU d'Oran en Algérie. *Alger J Health Sci.* 2021;3(2):22-29. [Google Scholar]
9. Ye W, Chen G, Li X, Lan X, Ji C, Hou M, et al. Dynamic changes of D-dimer and neutrophil-lymphocyte count ratio as prognostic biomarkers in COVID-19. *Respir Res.* 2020;21(1):169. [Google Scholar] [PubMed]
10. Chu M, Zhao X, Tang L, et al. The correlation of lymphocytes with disease progression of COVID-19. *Medicine (Baltimore).* 2023;102(48). [Google Scholar] [PubMed]
11. Trofin F, Nastase EV, Vâță A, et al. The immune, inflammatory and hematological response in COVID-19 patients, according to the severity of the disease. *Microorganisms.* 2023;11(2):319. [Google Scholar] [PubMed]
12. Zatla I, Boublenza L, Lemerini W, Triqui C, Selka N. Profiling COVID-19 cases in Tlemcen, Algeria: PCR and CT imaging insights. *COVID.* 2025;5(9):149. [Google Scholar]
13. Zatla I, Boublenza L, Boublenza A, Sebiane A, Salah I. COVID-19 in North Africa: an epidemiological analysis of cases, deaths, and vaccination efforts (2020-2023). *Infect Epidemiol Microbiol.* 2023;9(4):349-357. [Google Scholar]
14. Belhadj A, Yayaoui R, Zatla I, Sahraoui T. Uncovering clinical insights: a comprehensive analysis of COVID-19 cases in Oran from May to September 2021. *Euromediterr Biomed J.* 2024;19(14):67-70. [Google Scholar]
15. Russo A, Tellone E, Barreca D, Ficarra S, Laganà G. Implication of COVID-19 on erythrocytes functionality: red blood cell biochemical implications and morpho-functional aspects. *Int J Mol Sci.* 2022;23(4):2171. [Google Scholar] [PubMed]
16. Kondamangal S, Ghodeswar S, Saranya K. To study hematological profile in COVID-19 patients in relation with prognosis and outcome: a cross-sectional observational study. *Int J Adv Res.* 2023;11(4):604-610. [Google Scholar]
17. Melek NA, Allam MF, Labib BG, et al. Differential complete blood count for diagnosis of COVID-19? *World J Med Microbiol.* 2023;2:689. [Google Scholar]
18. Sacchi A, Giannessi F, Sabatini A, Percario ZA, Affabris E. SARS-CoV-2 evasion of the interferon system: can we restore its effectiveness? *Int J Mol Sci.* 2023;24(11):9353. [Google Scholar] [PubMed]
19. Liu MQ, Lin HF, Li J, Chen Y, Luo Y, Zhang W, et al. A SARS-CoV-2-related virus from Malayan pangolin causes lung infection without severe disease in human ACE2-transgenic mice. *J Virol.* 2023;97(2). [Google Scholar] [PubMed]
20. Kettunen P, Lesnikova A, Räsänen N, et al. SARS-CoV-2 infection of human neurons is TMPRSS2 independent, requires endosomal cell entry, and can be blocked by inhibitors of host phosphoinositol-5 kinase. *J Virol.* 2023;97(4). [Google Scholar] [PubMed]
21. Esquivel Gomez LR, Weber A, Kocher A, Kühnert D. Recombination-aware phylogenetic analysis sheds light on the evolutionary origin of SARS-CoV-2. *Sci Rep.* 2024;14:541. [Google Scholar] [PubMed]
22. Lee YK, Jeong SA, Park HC, et al. SARS-CoV-2 vaccine effectiveness and clinical outcomes in hemodialysis patients: the NHIS-COVID-19 cohort study in South Korea. *Front Public Health.* 2024;12:1372525. [Google Scholar] [PubMed]

23. Zatla I, Boublenza L, Boublenza A. Tracing the origin and early progression of COVID-19 in Europe: an epidemiological descriptive study. *Infect Epidemiol Microbiol.* 2023;9(3):249-256. [Google Scholar]
24. Allahverdiyeva A, Ağaçfıdan A, Dogan L, et al. Evaluation of SARS-CoV-2-positive patients with suspected reinfection. *Viruses.* 2023;15(11):2222. [Google Scholar] [PubMed]
25. Al-Jamal H, Idriss S, Roufayel R, Abi Khattar Z, Fajloun Z, Sabatier JM. Treating COVID-19 with medicinal plants: is it even conceivable? A comprehensive review. *Viruses.* 2024;16(3):320. [Google Scholar] [PubMed]
26. da Silva ACVF, Silva CAO, de Sousa GF, et al. Genomic surveillance and serological profile of SARS-CoV-2 variants circulating in Macaé and nearby cities, southeastern Brazil. *Front Microbiol.* 2024;15:1386271. [Google Scholar] [PubMed]
27. Sopjani M, Falco F, Impellitteri F, Guarrasi V, Nguyen Thi X, Dërmaku-Sopjani M, et al. Flavonoids derived from medicinal plants as a COVID-19 treatment. *Phytother Res.* 2024;38(3):1589-1609. [Google Scholar] [PubMed]
28. Zatla I, Boublenza L, Lemerini W, et al. Assessment of COVID-19 vaccination performance in Tlemcen: insights into vaccine inventory management. *Microbes Infect Dis.* 2025;6(3):1036-1043. [Google Scholar]
29. Teng X, Wang Z. Online COVID-19 diagnosis prediction using complete blood count: an innovative tool for public health. *BMC Public Health.* 2023;23:2536. [Google Scholar] [PubMed]
30. Waggiallah HA, Eltayeb MM, Hjadi AM, Elmosaad YM. High expression of angiotensin-converting enzyme 2 receptor (ACE-2), transmembrane protease serine (TMPRSS), and P-selectin in platelets lead to thrombosis formation in COVID-19 patients. *Eur Rev Med Pharmacol Sci.* 2024;28(5):1847-1856. [Google Scholar]
31. Lavado RF, Nowacka K, Raitzer DA, Rodgers YVDM, Zveglic JE. L'effet du COVID-19 selon le sexe et le revenu: l'exemple des Philippines. *Rev Int Trav.* 2022;161(1). [Google Scholar]
32. Ameur-Mansour M, Kaddour N. Study on the comparison of blood groups and haematological profile in people infected and uninfected by COVID-19 [master's thesis]. Tiaret, Algeria: Ibn Khaldoun University; 2023. p. 2-16. [Google Scholar]
33. Gupta C, Bhardwaj S. Patterns of complete blood counts (CBC) in patients with COVID-19 infection. *Pathology.* 2021;10(11). [Google Scholar]