A STUDY ON THE CORRELATION OF ELEVATED NEUTROPHIL-TO-LYMPHOCYTE RATIO AND PLATELET-TO-LYMPHOCYTE RATIO WITH COVID-19 MORTALITY AMONG PATIENTS IN A HOSPITAL ISOLATION WARD IN BALER, AURORA

ALLANY GAILE I. LANOT[1], JAZMIN D. CABAGNOT[2], ANGELA WYNETH T. DE LA CRUZ[3], DANIELLE THERESE S. IRINGAN[4], REINE ARIELLE M. MASANGKAY[5], FRANCESCA ANN C. MONES[6], ALISON GAIL A. SALVADOR[7], DARLA KIMBERLY M. TOLOSA[8], IAN PAULO C. GIGANTE[9]

http://orcid.org/: 0000-0003-2183-6854[1], http://orcid.org/: 0000-0001-9502-0909[2], http://orcid.org/: 0000-0002-3743-2750[3], http://orcid.org/: 0000-0003-1000-6273[4], http://orcid.org/: 0000-002-0433-9517[5], http://orcid.org/: 0000-0002-4882-2228[6], http://orcid.org/: 0000-0002-5903-6820[7], http://orcid.org/: 0000-0002-8237-3104[8], http://orcid.org/: 0000-0002-4064-3209[9]

allanygaile.lanot.pharma@ust.edu.ph[1], jazmin.cabagnot.pharma@ust.edu.ph[2], angelawyneth.delacruz.pharma@ust.edu.ph[3], daniellетherese.iringan.pharma@ust.edu.ph[4], reinearielle.masangkay.pharma@ust.edu.ph[5], francescaann.mones.pharma@ust.edu.ph[6], alisongail.salvador.pharma@ust.edu.ph[7], darlakimberly.tolosa.pharma@ust.edu.ph[8], icgigante@ust.edu.ph[9]

University of Santo Tomas, Manila, Philippines[1-9]

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ABSTRACT

Neutrophil-to-Lymphocyte Ratio (NLR) and Platelet-to-Lymphocyte Ratio (PLR) are inflammatory biomarkers known to assess several disease types effectively. With the surge of Coronavirus disease (COVID-19) cases, many patients manifested various systemic inflammatory conditions suggesting a possible relationship between the predictive values of NLR and PLR to COVID-19 mortality. The study aims to assess a correlation between elevated biomarker values of NLR and PLR with COVID-19 mortality. A single-center, cross-sectional study of COVID-19 patients, admitted to a hospital isolation ward in Baler, Aurora, between May to October 2021 was conducted. Secondary data, namely demographic profiles, complete blood count results, and comorbidities upon admission, were collected. The effect of NLR and PLR on the risk of mortality, along with the impact of covariate variables that may affect the study's outcome, was determined using a multiple binary logistic regression model and the computation of the odds ratio. 264 COVID-19 patients were included in the study–202 were recovered and 62 were deceased. Multiple binary logistic regression demonstrated a higher mortality risk in patients with elevated NLR (OR=2.607; 95% CI: 1.276 to 5.324; p=.009). Other risk factors such as age (OR=1.053; 95% CI: 1.029 to 1.077; p<.001) and diabetes mellitus (OR=3.537; 95% CI: 1.441 to 8.682; p=.006) are risk factors for COVID-19 mortality. Patients with elevated NLR values indicate poor clinical outcomes with a higher mortality risk compared to those with low NLR in COVID-19 patients. Moreover, age and diabetes must be considered in patient assessment upon admission due to their correlation to COVID-19 mortality.

Keywords: COVID-19 mortality, inflammatory biomarker, Neutrophil-to-Lymphocyte Ratio (NLR), Platelet-to-Lymphocyte Ratio (PLR).

INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is a significantly infectious respiratory disease induced by its causative agent, severe acute respiratory syndrome coronavirus 2 (SARS- CoV-2). Since its initial recorded manifestation in Wuhan, China, in December 2019, COVID- 19 has established its propagation around the world, resulting in millions of documented cases and deaths. On January 31, 2020, the initial case of COVID-19 in the Philippines was identified at San Lazaro Hospital. Subsequently, the country implemented various travel restrictions and regional quarantine lockdowns in response to confirmed cases of local transmission on March 5, 2020 (Edrada et al., 2020). Infectious diseases are indicative of inflammation, as cell destruction leads to cytokines and chemokines from the activated macrophages. Immune responses are activated against the replication stages of SARS-CoV-2, causing physiological inflammatory states. As such, patients diagnosed with severe COVID-19 symptoms have a poor prognosis, with hyper inflammation being a leading reason (Zeng et al., 2020). Emerging studies have shown that hematological parameters may serve as markers for systemic inflammation. Hence, viral infections may cause hematological changes, specifically in the different white blood cells. Neutrophil-to-Lymphocyte Ratio (NLR) is derived by dividing the absolute neutrophil count of the patient by his absolute lymphocyte count (Martins et al., 2019). NLR is a good indicator of systemic inflammation, having been used in the differentiation of infection and as a novel subclinical biomarker for cardiovascular, oncological, and infectious diseases (Palacios Huatuco et al., 2021). Platelet-to-Lymphocyte Ratio (PLR) is calculated by dividing the platelet count by the absolute lymphocyte count of the patient (Jain et al., 2021). It is a prognostic biomarker used to predict inflammation and mortality in patients with cardiovascular and autoimmune diseases (Simadibrata et al., 2022). Several studies have shown that since COVID-19 cascades into a systemic inflammatory response, both NLR and PLR can be utilized to determine mortality outcomes and disease severity. However, the individual diagnostic effectivity of NLR and PLR has yet to be evaluated, especially within a local context. Although various COVID-19 profiles of hematological parameters have already been documented, the majority of these analyses were derived from Chinese (Wang et al., 2020) and Western (Chan et al., 2020) locales; hence, there is a need for research that assesses specific hematological parameters, specifically NLR and PLR, as biomarkers for COVID-19 in the Philippine setting. This study strives to evaluate the mortality risk of COVID-19 admitted individuals in a local hospital in Aurora using NLR and PLR values. The findings of this study hope to significantly improve the knowledge deficit of epidemiological and hematological parameters among COVID-19 patients in the Philippine population and further define the future of COVID-19 diagnosis in the Philippines.

Figure 1 illustrates the conceptual framework utilized in this paper. The elevated values of inflammatory markers, specifically the NLR and PLR of COVID-19 patients gathered during a routine blood test are the independent variables. Meanwhile, the risk of mortality among COVID-19 individuals is the dependent variable in the study. Demographic variables, precisely age and gender; underlying medical conditions of participants such as arterial hypertension, diabetes mellitus, and community-acquired pneumonia (CAP) are the variables that may affect both the exposure and outcome variables. Hence, these must be considered in conducting the study to ensure the validity of the results.

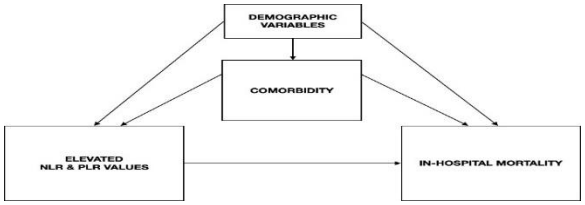

Figure 1. Conceptual Framework

Figure 2 illustrates the theoretical framework utilized in the study. NLR and PLR are readily available indicators of the systemic inflammatory response (Man et al., 2021). According to Feng et al. (2020), an increase in neutrophil count and decrease in lymphocyte count is an indication of severe response of the body and the intensity of the acuteness the consequent immunological damages. In Qu et al.'s (2020) study, lower counts of platelets and lymphocytes is associated with disease severity and extended hospital stay. Meanwhile, it was also observed in a study by Jain et al. (2021), that elevated PLR values were observed in severe patients compared to non-severe patients. Severe COVID cases and high mortality rates were associated with both parameters being elevated (Li et al., 2020). Consequently, the present study employed NLR and PLR as its primary predictive variables in the disease mortality of COVID-19, with the assumption of elevated NLR and PLR in the deceased group, as a previous study by Yang et al. in 2020, revealed that a positive correlation between the markers was present.

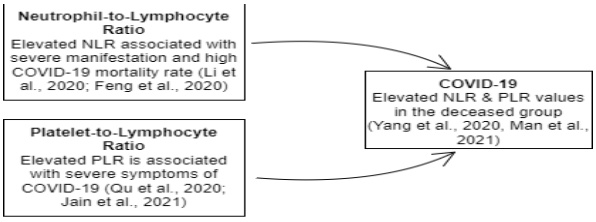

Figure 2. Theoretical Framework

OBJECTIVES OF THE STUDY

The general objective of the study aims to assess a correlation between elevated biomarker values of NLR and PLR and mortality from COVID-19. Specifically, it aims to 1) determine if the odds ratio of elevated NLR and PLR values among COVID-19 patients who eventually died of the disease is greater than 1 (>1); and 2) determine if an elevated NLR or PLR is a risk factor for COVID-19 mortality.

METHODOLOGY

A single-center, cross-sectional design was utilized in this study, in which a non- clinical trial approach of reviewing medical records will be adopted. The design allowed the researchers to conduct the study at one point in time and collect secondary anonymized data on the patient's demographics and neutrophil, lymphocyte, and platelet count. The parameters were taken from their complete blood count results upon admission to assess the correlation of high NLR and PLR values with COVID-19 mortality.

The data obtained from a hospital in Baler, Aurora, were collected from May 2021 to October 2021. The study's population consisted of all confirmed COVID-19 patients in Baler, Aurora, Philippines. The patients were categorized into recovered and deceased groups. The selection of COVID-19 patients was based on the hospital's classification of critical patients upon testing with a rapid antigen test prior to confirmation with rRT-PCR. Demographic information, including all subjects' age, gender, and comorbidities, was extracted from the hospital records through the authorized records department staff. The clinical data, particularly the patient history or comorbidities and complete differential count collected, was based on the records of the patients upon the first day of hospital admission.

Confirmed COVID-19 patients younger than 18, pregnant women, those admitted before May 2021 and after October 2021, and patients that were initially treated and/or admitted in the hospital isolation ward in Baler, Aurora but were transferred to other hospitals were excluded from the study. Moreover, deceased or recovered patients admitted before May 2021 but discharged from the hospital between May to October 2021 and those admitted between May to October 2021 but discharged after the study's time frame were not included.

The research included a sample of 264 participants. Statistical analysis, utilizing SPSS

version 25.0, was conducted on the data concerning absolute neutrophil, lymphocyte, and platelet counts for the computation of NLR and PLR. The demographics and blood parameters taken from the complete differential count were analyzed and summarized using means and standard deviation, as well as median and interquartile ranges. The effect of NLR and PLR on the risk of mortality, along with the impact of covariate variables that may affect the study's outcome, was determined using a multiple binary logistic regression model. The cut-off values used in determining the elevated NLR and PLR levels were 3.3 and 180, respectively, based on the study conducted by Yang et al. (2020).

RESULTS AND DISCUSSION

1. Demographics

Table 1
Demographic Profile and Results of NLR and PLR in Recovered and Deceased

Characteristics	All (*n* = 264)	Recovered (*n* = 202)	Deceased (*n* = 62)	*p*-value
Age (years)				
Median	57 (42-68.5)	65 (56-78)	54 (38-64)	<00.1
Mean	55.38±17.18	52.16±16.97	65.89±13.34	
Gender				
Male, *n* (%)	122 (46.22%)	97 (36.74%)	25 (9.48%)	.103
Female *n* (%)	142 (53.78%)	105 (39.77%)	37 (14.01%)	
Neutrophils (x10^9 cells/L)	74.49±16.15	72.36±16.68	81.44±11.99	-
Lymphocytes (x10^9 cells/L)	23.54±14.24	25.93±14.59	15.74±9.57	-
Platelets (x10^9 cells/L)	228.70±207.78	229.34±231.23	226.61±99.79	-
Neutrophil-to-Lymphocyte Ratio (NLR)	5.07±4.61	4.11±3.36	8.20±6.43	.009
Platelet-to-Lymphocyte Ratio (PLR)	14.77±17.75	12.06±13.89	23.57±24.88	-
Comorbidities				
Arterial Hypertension, *n* (%)	195 (73.86%)	146 (55.30%)	49 (18.56%)	.152
Diabetes Mellitus, *n* (%)	39 (14.77%)	24. (9.09%)	15 (5.68%)	.006
Community-Acquired Pneumonia, *n* (%)	14 (5.30%)	14 (5.30%)	0	.998

Among the demographic characteristics, there was sufficient evidence that only age (p<.001) reflected a significant correlation with patients' mortality from COVID-19. According to a study conducted by Yang et al. in 2020, elevated NLR and PLR levels had a positive correlation with the patient's age which appeared to have a good diagnostic and predictive role in COVID-19. This was in line with the present study findings, given that the likelihood of individuals passing from COVID-19 increases significantly with age (OR=1.053; 95% CI: 1.029–1.077). The median age of 57 was recorded, which similarly reflected the median age recorded from a previous study featuring in-patients from a large multi-hospital healthcare system in the United States (Rivera et al., 2021). Additionally, a prospective single-center study by Liu et al. (2020) recorded a median age of 53 among Chinese patients, which was closer to the current study compared to 72 years old which was reflected by Regolo et al. (2022) consisting of subjects from two hospitals in Italy. However, it is also important to consider if there is an equal distribution of patients included in the study coming from different age groups to ensure the reliability of the data gathered in making claims as far as age is concerned. Moreover, the probability of acquiring more severe COVID-19 symptoms might be influenced by several underlying diseases experienced by a patient as they get older. Age as a notable predictor of COVID-19 fatality can be used in the hospital setting as a means to stratify disease severity and mortality. Such demographic characteristic is readily available and essentially not difficult to obtain upon hospital admission. Similarly, the additional assessment of these factors could further aid health practitioners in their provision of appropriate medical care to their patients.

Furthermore, sex (p=.103; 95% CI: .896–3.292) was not found to be a factor for COVID-19 risk mortality. There were also no statistically substantial disparities observed between the gender classifications upon analysis that was found to be similar to the findings of Nalbant et al. (2020). A probable reason for such findings could

be due to several factors, including the limited sample size and the unequal number of male and female patients.

2. Comorbidities

Table 2
Summary of Logistic Regression Analysis for Variables Predicting the Patients' Mortality from COVID-19

Variables	B	SE	*p*-value	OR	95% Confidence Interval	
					Lower	Upper
Sex	.541	.332	.103	1.717	.896	3.292
Age (years)	.051	.011	<0.001	1.053	1.029	1.077
NLR	.958	.364	.009	2.607	1.276	5.324
Hypertension	.605	.423	.152	1.831	.800	4.193
Diabetes	1.263	.458	.006	3.537	1.441	8.682
CAP	-19.349	9544.404	.998	.000	.000	
Constant	-5.804	.921	<.001	.003		

A multiple binary logistic regression was conducted using NLR, PLR, age, gender, and main comorbidities as the independent variables and status of the patient (deceased or recovered) as the outcome variable, as presented in Table 4.2. The statistical analysis showed that age (p< .001), NLR (p=.009), and diabetes mellitus (p=.006) are possible risk factors for a patient's mortality from COVID-19. Among the variables, diabetes showed the most significant association with COVID-19 mortality (OR = 3.537, 95% CI: 1.441 - 8.682), followed by NLR (OR = 2.607, 95% CI: 1.276 - 5.324).

Among the included comorbidities established as variables, only diabetes mellitus (p=.009) was considered a risk factor for patients' mortality from COVID-19. The odds that a patient will die of COVID-19 is 3.537 (95% CI: 1.441–8.682) times more when a patient has diabetes. The present findings partly agree with the meta-analysis of Zheng et al. (2020) that the number of diabetic patients was essentially greater in the critical group compared to the non-critical group. In contrast to the current results wherein hypertension (p=.152; 95% CI: .800–4.193) was not deemed a risk factor for COVID-19 mortality, the aforementioned meta-analysis established a notable relationship between hypertension and COVID-19 disease progression. The analysis, however, only investigated patients of Chinese ethnicity across the 13 articles with 3027 participants. Additionally, hypertension generated a heterogeneity of I^2 = 72%, in which the severity of illness and severity of epidemic were hypothesized to be contributors. When present in a COVID-19 patient, such chronic comorbidities induce a state of stress, weakened immunity, and a damaged vasculature structure, resulting in an increased risk of developing into critical disease.

Tatum et al. (2020) also shared a similar picture of the most common COVID-19 comorbidities, with diabetes and hypertension as its two leading frontrunners among predominantly African-American populations, further elucidating that hypertension disease rates vary by ethnicity. Their investigations also concluded that diabetes may result in a greater risk of infection caused by impaired mechanisms of innate immunity and low-grade chronic inflammation. Despite the large hypertensive population in the present study, the weakened role of hypertension in mortality could also be attributed to its varying severity across patients. Previous distinctions of severity were mostly established based on blood pressure levels and medication use, in which impaired cognitive performance (Muela et al., 2017) and cardiovascular disease-related mortality (Grandi et al., 2019) were found to be associated with hypertension severity.

CAP was also presumed to be correlated to patient mortality, considering that a high incidence of CAP was recorded during the COVID-19 pandemic as observed by Chemisova et al. (2022), along with a higher risk of developing other types of pneumonia. However, there were limited references suggesting that there is a significant correlation between CAP and COVID-19 mortality since a majority of these analyses focused on the manifestation of CAP on disease severity.

Similarly, it was established that patients with CAP had higher incidences of hypertension, lung disease, and diabetes compared to those infected with COVID-19 (Liu et al., 2020). No further data regarding the mortality and survival rate in the aforementioned studies revealed any significant correlation between CAP with COVID-19. Such findings support the current study in which CAP (p<.998; OR=.000; 95% CI: .000) was not established as a risk factor for patient mortality from COVID-19, as all patients in the dataset suffering from CAP and COVID-19 managed to recover. Additionally, CAP's potential in being a risk factor for COVID-19 mortality might be underestimated due to the minimal sample size utilized in the research and the limited number of patients with the comorbidity (5.30%).

Furthermore, Dávila-Collado et al. (2021) suggested that certain comorbidities, particularly asthma and diabetes, did not correlate with COVID-19 mortality as several predisposing factors may be attributed to the deaths, such as nutritional deficiency in terms of vitamins and diet triggering different infections in the body. Essentially, the comorbidities are non-specific in establishing a trend in deaths due to COVID-19. The underlying conditions experienced by the patient must not be the sole basis of being a prognostic tool for any disease for that matter. Nonetheless, it is vital to consider the association of COVID-19 outcomes with comorbidities, specifically diabetes mellitus, and corresponding medications in the development of preventive and therapeutic measures for these patients.

3. Hematological parameters

The primal aim of this research was to determine a correlation between elevated biomarker values, NLR and PLR, with COVID-19 mortality. A significant association between NLR (p=.009) and patients' mortality from COVID-19 was established. Retaining the other variables constant, the odds that a patient will die of COVID-19 is 2.607 (95% CI: 1.276–5.324) times more when a patient has elevated levels of NLR. The findings of the study agree with the hypothesis of Tatum et al. (2020). Although their study utilized different methods, seeming as Tatum assessed the predictive capability of NLR whilst establishing cut-off values, both studies still arrived at the same findings, that elevated levels of NLR may be used as a biomarker for prognosis and mortality. NLR is a prominent indicator of systemic inflammatory response; thus, it is expected that a higher value is correlated with disagreeable outcomes in individuals with COVID-19. This is further supported by the cross-sectional analysis of Albarrán-Sánchez et al. (2020), which examined NLR and LCR. This study stated that an NLR value of >12 was associated with increased COVID-19 mortality, showing that NLR proves to be a risk factor in mortality studies regardless of its accompanying hematological parameter variable. Nonetheless, both studies still mirrored similar NLR findings. Among the vast related literature reviewed, none have established that NLR is not correlated with mortality from COVID-19.

On the other hand, there was no evidence showing that PLR was a risk factor for patients' mortality from COVID-19 despite being hypothesized to significantly affect disease outcomes. Upon statistical analysis, PLR as a predictor variable was not reflected in the regression analysis because none of the PLR values in the dataset were elevated (14.77 ± 17.75; PLR cut-off >180). Wool and Miller (2021) discussed that patients with severe COVID-19 exhibited mild thrombocytopenia compared to the patients with non-severe symptoms. Additionally, the deceased patients exhibited lower platelet counts than those who survived. However, as an established inflammatory marker, PLR was expected to be observed among patients with a poor prognosis due to the critical role that inflammation plays in COVID-19 pathophysiology. In a study conducted by Sharma et al. (2021), the PLR did not significantly elevate as represented by the difference between the survived and deceased groups (p=0.580), which is possibly attributed to

regular platelet transfusions, prompt inflammation control in critically ill patients in the study's ICU, and effective thrombocytopenia treatment. The research also highlighted that a single measurement of PLR cannot be utilized as a measure of COVID-19 progression and that a repeat PLR is necessary for the final examination.

However, according to Sarkar et al. (2022), PLR values were significantly increased in critical COVID-19 patients in comparison to healthy individuals. The meta-analysis examined 33 studies with 29 peer-reviewed and 3 preprints; however, the quality of evidence with regards to the impact of elevated PLR is low. The results of the cut-off meta-analysis are heterogeneous with a medium effect which means that PLR values upon admission were variable, and the cut-off value of PLR during the conduct of the study was not well-established. This may explain the difference in the results obtained in the current study. Moreover, Jain et al.'s (2021) study suggests that both NLR and PLR can be effective screening tools to predict disease prognosis. The objective of the research was to evaluate the role that PLR plays as a risk factor for COVID-19 severity. However, only 4 mortality were included with 3 of the cases being aged 80 years and above, while 187 have recovered. In comparison with the present study, with 62 out of 264 sample size were deceased, the difference in the distribution among study groups can be a possible factor why the present study and the study of Jain et al. (2021) have different results.

A specific pursuit of the study was to resolve whether the odds ratio of elevated NLR and PLR values among deceased COVID-19 patients was greater than 1 (>1). From the two ratios mentioned, only the elevated NLR values (OR = 2.607) were found to have an odds ratio greater than 1. In a study by Yang et al. (2020), the analysis of multivariate factors considered NLR to be positively correlated with death (OR = 2.886, 95% CI: 2.064–4.860, p=0.019), which is in line with the result of the study that there are 2.607 (95% CI: 1.276 – 5.324) times more patients who eventually died compared to those who survived. Neutrophils are usually activated by interleukin 8 and interleukin 6 which are virus-related inflammatory factors, and the virus-triggered immune response relies primarily on lymphocytic cells. Hence, inflammation caused by the virus elevates NLR values, which encourages disease progression, implying that NLR may be associated with the severity and prognosis of the infection. In a study by Singh et al. in 2021, the PLR values on day 1 and day 3, p=0.57 and p=0.54, respectively, were not statistically significant in survivors as compared to nonsurvivors. In the multivariable analysis for factors related to disease severity, PLR was also not significant (p= 0.45). The values may have been affected as steroids, which can cause leukocytosis, have been used among patients in the study. PLR is also a time-sensitive variable; thus, dynamic values may have been recorded. The study was also single-centered and called for multicenter studies with a large sample size.

The retrospective cohort study of Wang et al. (2020) supports the overall results of this research, indicating that while NLR (OR=1.513, 95% CI: 1.101-263, p= 0.044) is a reliable indicator of all-cause mortality in individuals with COVID-19, PLR is not. The time frame of data collection was from February 13 to March 14 of 2020, wherein COVID-19 was still new, and information about the disease was limited. NLR and PLR cut-off values were also not yet well-established. The data were gathered from the number one hospital in Wuhan as compared to this study where data was gathered from a primary hospital in Baler, Aurora. The source of data is a major factor since the related study has more complete healthcare facilities and equipment compared to a primary hospital. Both studies collected the hematological parameters during the first day of hospital admission. The related study had a fewer sample size of 131, and only 12 were non-survivors, which according to the limitation of the study, underestimated the PLR value in predicting COVID-19 mortality. Their study found that NLR (p< 0.001) was significantly correlated with COVID-19 mortality and the odds that a patient will die is 1.513 (95% CI: 1.385-2.498) times when the patient has elevated NLR upon admission. The

NLR cut-off value used in the study of Wang et al. is 3.3 which is also the cut-off value used in the present study showed high prognostic possibility with 84% specificity and 100% sensitivity. However, PLR (p=0.274) shows no significant correlation with COVID-19 mortality, with a 1.002 (95% CI: 0.998-1.007) times probability that the patient will not survive with elevated PLR upon admission. These results were further supported by the study conducted by Velazquez et al. (2021) with only NLR (p<0.0001) having a significant correlation with ICU admission. Patients requiring ICU admission show a high-velocity ascent of NLR, but the rate of PLR did not significantly change.

CONCLUSION

The analysis showed that age (p<.001), NLR (p=.009), and diabetes mellitus (p=.006) are risk factors for a patient's mortality from COVID-19. Keeping the other variables constant, the odds that a patient will die of COVID-19 due to an elevated NLR, diagnosed with diabetes mellitus, and an increase of age by 1 year is 2.607 (95% CI: 1.276 – 5.324), 3.537 (95%CI: 1.441 – 8.682), and 1.053 (95% CI: 1.029 – 1.077), respectively. Furthermore, all other variables (sex, PLR, hypertension, and CAP) are not correlated with COVID-19 mortality. Among the two hematological parameters tested, only elevated NLR upon admission appeared to have a significant correlation with COVID-19 mortality. This result implies that patients with high NLR values indicate poor clinical outcomes with a higher mortality risk compared to those with low NLR in COVID-19 patients. With regards to demographics, the study found that only age had a significant correlation with COVID-19 mortality. The results suggested that the older a patient is, the higher the odds that they could die due to COVID-19. Moreover, diabetes mellitus was the only comorbidity that showed a significant potential of being a predictor for mortality. The probability of survival from COVID-19 among diabetic patients was found to be almost four times less likely to happen compared to those who do not have the disease. As such, the age demographics of patients and existing comorbidities, specifically diabetes, must be taken into consideration in assessing the patient upon admission, given how these factors can significantly increase the probability of death attributed to COVID-19. Based on the gathered data, none of the PLR values of patients upon admission were elevated; consequently, PLR shows no significant correlation with COVID-19 mortality. Sex, on the other hand, was not found to have a statistical correlation with the disease. Furthermore, the study did not observe any noteworthy differences between the gender groups. Underlying conditions, particularly hypertension and CAP, were not considered to be significantly valuable in the study. Simply put, the aforementioned comorbidities, along with PLR values and sex, must not be used as lone predictors for COVID-19 mortality.

Hematologic parameters could potentially be used as a rapid and early risk stratification tool to assess COVID-19 severity and mortality. Markers such as NLR and PLR examined in this study are routinely collected through CBCs before patient admission, making these parameters accessible in the healthcare setting, especially in areas with limited resources and hard to obtain biochemical markers are not readily available. According to the results of the study, only NLR had a significant correlation with COVID-19 mortality. However, the threshold of NLR in categorizing severity and mortality is still not well-established and studied; thus, the need for meta-analysis and systematic review to evaluate NLR predictive values and to establish different thresholds.

RECOMMENDATION

The researchers recommend including a bigger study population within multiple hospital institutions to eliminate selection bias. A larger study sample may aid in establishing a more accurate relationship between NLR, PLR, and other comorbidities with COVID-19 mortality. A baseline cut-off value for both NLR and PLR should also be established as a point of comparison for

deceased and recovered COVID-19 patients, as well as normal and healthy individuals.

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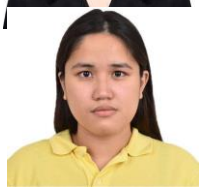
AUTHORS' PROFILE

Allany Gaile I. Lanot, Bachelor of Science in Medical Technology in University of Santo Tomas.

Jazmin D. Cabagnot, Bachelor of Science in Medical Technology in University of Santo Tomas.



Angela Wyneth T. De La Cruz, Bachelor of Science in Medical Technology in University of Santo Tomas.

Danielle Therese S. Iringan, Bachelor of Science in Medical Technology in University of Santo Tomas.

Reine Arielle M. Masangkay, Bachelor of Science in Medical Technology in University of Santo Tomas.

Francesca Ann C. Mones, Bachelor of Science in Medical Technology in University of Santo Tomas.

Alison Gail A. Salvador, Bachelor of Science in Medical Technology in University of Santo Tomas.

Darla Kimberly M. Tolosa, Bachelor of Science in Medical Technology in University of Santo Tomas.

Ian Paulo C. Gigante, Instructor at the University of Santo Tomas, Manila. Medical Laboratory Scientist with Masters in Public Health.

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