ORIGINAL ARTICLE

Comparative Analysis of Erythrocyte, Leukocyte, and Platelet Indices through Examinations Using Sysmex XN-3000 and Yumizen H2500 in Clinical Practice

Yuniar Putri Wardani[1], Yulia Nadar Indrasari[2*], Putu Niken Ayu Amrita[3,4], Muhamad Robi'ul Fuadi[2]

[1]Medical Study Program, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[2]Department of Clinical Pathology, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
[3]Division of Hematology and Medical Oncology, Department of Internal Medicine, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
[4]Indonesian Association of Internal Medicine

ABSTRACT

Introduction: Examining erythrocyte, leukocyte, and platelet indices is critical for diagnosis, disease management, therapy selection, and monitoring. It is imperative to evaluate the hematology analyzer used for a complete blood examination, as each device possesses distinct specifications, methods, and technologies. This study aimed to compare complete blood count parameters, specifically the erythrocyte, leukocyte, and platelet indices, using Sysmex XN-3000 and Yumizen H2500.

Methods: This cross-sectional study used blood samples from adult outpatients aged >18 years at Dr. Soetomo General Academic Hospital, Surabaya, Indonesia. Samples were collected using purposive sampling, resulting in 100 blood specimens for complete blood count analysis. The examined variables included erythrocyte, leukocyte, and platelet indices, which were compared across two different instruments, i.e., Sysmex XN-3000 and Yumizen H2500. The data were analyzed using either the Spearman or Pearson correlation test ($p<0.05$). The Bland-Altman plotting was employed to assess the differences between variables, with a minimum of five agreed-upon outliers.

Results: Significant correlations were observed across all parameters, except for the mean corpuscular hemoglobin concentration (MCHC), which showed limited agreement in the Bland-Altman analysis. The Pearson and Spearman analyses revealed a significant correlation in the parameters of erythrocytes (0.00), leukocytes (0.00), and platelets (0.00). The Bland-Altman plot indicated seven outliers in the average MCHC values from the two analyzers, demonstrating insufficient agreement.

Conclusion: There is significant agreement and correlation in the erythrocyte, leukocyte, and platelet indices from both analyzers. This finding affirms the compatibility of both instruments for clinical use, with caution advised when interpreting MCHC values.

Keywords: Sysmex XN-3000; Yumizen H2500; hematology analyzer; medical technology; medicine

Correspondence: Yulia Nadar Indrasari
E-mail: yulia.nadar@fk.unair.ac.id

Highlights:
1. This study evaluated the validity of different hematology analyzers for complete blood count examinations in medical laboratories, a topic that has rarely been discussed in detail.
2. The results of this study are expected to contribute to the quality improvement of medical laboratory technologies in Indonesia.

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INTRODUCTION

Clinical laboratory tests play an important role in supporting diagnosis, disease management, therapy selection, and monitoring. It is estimated that 60–70% of clinical decisions are supported by clinical laboratory results (Olver et al., 2023). Clinical laboratories provide examination services in various fields, including hematology, clinical chemistry, clinical microbiology, clinical parasitology, clinical immunology, and other areas related to individual health, particularly to support in vitro diagnostic efforts (Sosmira et al., 2021).

Hematological testing is one of the most commonly utilized services in clinical laboratories. It is conducted to assess the condition of the blood and its components, including routine blood tests and complete blood counts (Bararah et al., 2017). Parameters measured in a routine blood test include platelet counts, leukocyte counts, hematocrit levels, and hemoglobin concentrations. Meanwhile, a complete blood count test includes the parameters of a routine blood test along with erythrocyte

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indices, platelet indices, and leukocyte differentials (Gunawardena et al., 2017).

Erythrocyte indices are used to assist in diagnosing various types of anemia as well as detecting abnormalities in the production and function of erythrocytes and the risk of cardiovascular disease complications (Setiawan et al., 2014). Prior research has reported that changes in platelet indices are associated with abnormalities in the coagulation activation system, infections, trauma, systemic inflammatory response syndrome, thrombosis, and cardiovascular diseases (Budak et al., 2016). Concurrently, routine leukocyte count examinations in laboratories are also used to assess the function of the immune system (Salman et al., 2021).

Aligned with the critical role of complete blood count in clinical practice, the use of hematology analyzers is essential. Hematology analyzers are capable of automatically analyzing various blood components, including erythrocytes, leukocytes, and platelets (Maciel et al., 2014). These instruments enhance the accuracy and speed of complete blood count processing, reducing cell counting duration from 5–10 minutes per sample with manual microscopy to merely 15 seconds (Berta et al., 2024; Daves et al., 2024). In the current era of advanced technology, the development of hematology analyzer features has progressed rapidly. Numerous types of hematology analyzers are available, such as the Sysmex XN-3000 and Yumizen H2500 that have been utilized in Dr. Soetomo General Academic Hospital, Surabaya, Indonesia. This study was conducted to compare the accuracy, sensitivity, and efficiency of the Sysmex XN-3000 and Yumizen H2500 hematology analyzers in the analysis of erythrocyte, leukocyte, and platelet indices.

METHODS

An analytical observational study was conducted using a cross-sectional approach to determine whether there were significant differences in the measurements of erythrocyte, leukocyte, and platelet indices between the Sysmex XN-3000 and Yumizen H2500 hematology analyzers. The study was carried out from November to December 2023. The research samples consisted of outpatients undergoing complete blood count examinations at the laboratory of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia. Sampling was carried out using a purposive sampling technique, based on considerations or specific characteristics (Campbell et al., 2020). The inclusion criteria for this study encompassed adult patients aged over 18 years. A total of 100 samples were obtained. The data collection was carried out by performing complete blood count tests on each blood sample using two different instruments, namely the Sysmex XN-3000 and the Yumizen H2500. Erroneous or unreadable results from the complete blood count tests were excluded from the study.

The dependent variables consisted of erythrocyte, leukocyte, and platelet indices. The erythrocyte indices included red blood cells (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red blood cell distribution width-coefficient of variation (RDW-CV), and red blood cell distribution width-standard deviation (RDW-SD) (Hidayah et al., 2020). The leukocyte indices comprised white blood cell (WBC) parameters, including complete leukocyte differential counts and absolute counts representing the quantity of each white blood cell type: eosinophils (EOS#), basophils (BASO#), neutrophils (NEU#), lymphocytes (LYM#), and monocytes (MON#) (Rinawati & Reza, 2016). The platelet indices encompassed platelet count (PLT), platelet distribution width (PDW), mean platelet volume (MPV), platelet large cell ratio (P-LCR), and plateletcrit (PCT) (Pogorzelska et al., 2020).

The independent variables in this study were the Sysmex XN-3000 and Yumizen H2500 hematology analyzers. The Sysmex XN-3000 was capable of measuring a total of 46 parameters, with a nominal capacity of 200 samples per hour for complete blood count throughput and 120 samples per hour for staining. The Sysmex XN-3000 employed hydrodynamically focused direct current (DC) for measuring erythrocytes, platelets, and leukocytes, and used fluorescence flow cytometry to measure leukocyte differentiation, reticulocytes, and platelets (Sysmex Indonesia, 2021). The Yumizen H2500 utilized the double hydrodynamic focusing method and provided measurements of a total of 55 parameters. It could process up to 120 samples per day (Horiba Medical, 2020). The Yumizen H2500 and Sysmex XN-3000 hematology analyzers had distinct specifications and operating methods.

The obtained test results were processed using the Kolmogorov-Smirnov normality test to assess the data distribution. The data were considered normally distributed if the significance value was above 0.05 (Krithikadatta, 2014). The Pearson correlation analysis was used for normally distributed data. If the data were not normally distributed, an alternative correlation analysis using the Spearman test was conducted (Cleophas & Zwinderman, 2018). A variable was determined to have a significant correlation if the p-value was lower than 0.05. The correlation coefficient was measured to indicate the strength of the correlation, categorized according to standard ranges (i.e., weak, moderate, strong, and very strong). The Bland-Altman plot was employed to evaluate agreement by assessing the bias between the two measurement methods, analyzing the average differences, and estimating the agreement interval through the limit of agreement (LoA). The data processing was performed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Characteristics of the research subjects

The age range of the study samples varied between 18 and 76 years. Table 1 shows that the majority of the subjects belonged to the young adult and middle-aged adult groups, totaling 69 individuals (69%). Meanwhile, the remaining 31 research subjects (31%) were elderly. The distribution of research subjects by sex categorization indicated that most participants were female, with 71 individuals (71%). The smaller proportion of the research subjects were male, comprising 29 individuals (29%).

Table 1. Distribution of the research subjects by age and sex categorization

Characteristics	n	%
Age (years)		
Young and middle-aged adults (18–59)	69	69
Elderly (>60)	31	31
Sex		
Female	71	71
Male	29	29

Table 2. Mean correlation test results and limits of agreement for Yumizen H2500 and Sysmex XN-3000

Variables	Mean		MD	SD	Agreement		p	r
	Yumizen H2500	Sysmex XN-3000			Upper limit	Lower limit		
Erythrocyte indices								
RBC	4.12	4.15	-0.032	0.12	0.2	-0.27	0.00[a]	0.983
HGB	11.82	11.85	-0.003	0.345	0.67	-0.68	0.00[a]	0.963
HCT	35.68	35.42	0.16	1.5	3.1	-2.78	0.00[a]	0.839
MCV	87.01	84.56	1.03	2.5	5.93	-3.87	0.00[b]	0.841
MCH	28.72	28.42	0.3	0.39	1.06	-0.5	0.00[b]	0.859
MCHC	33.10	33.17	-0.08	1.06	2	-2.16	0.00[b]	0.432
RDW-CV	14.29	14.52	-0.27	1.06	1.8	-2.35	0.00[b]	0.845
RDW-SD	44.80	44.83	-0.52	4.1	7.52	-8.56	0.00[b]	0.646
Leukocyte indices								
WBC	8.58	8.50	0.052	0.52	1.1	-0.1	0.00[b]	0.987
NEU	65.07	63.93	0.12	1.31	2.7	-2.45	0.00[b]	0.963
LYM	24.40	24.59	0.25	1.62	3.5	-3	0.00[a]	0.835
MONO	7.24	7.82	-0.58	0.66	0.72	-1.9	0.00[b]	0.921
EOS	2.61	2.73	-0.12	0.37	0.62	-0.85	0.00[b]	0.913
BAS	0.51	0.32	0.2	0.24	0.67	-0.27	0.00[b]	0.492
Platelet indices								
PLT	300.86	312.51	-9.85	21.1	31.51	-51.21	0.00[b]	0.957
PDW	10.78	12.83	-2.2	1.4	0.54	-4.94	0.00[b]	0.817
MPV	9.90	9.56	0.3	0.5	1.28	-0.68	0.00[a]	0.827
PCT	0.29	0.30	-0.0006	0.022	0.043	-0.044	0.00[b]	0.939
P-LCR	23.52	24.37	-0.983	3.37	5.41	-7.38	0.00[a]	0.864

Notes: LDL=low-density lipoprotein; HDL=high-density lipoprotein.

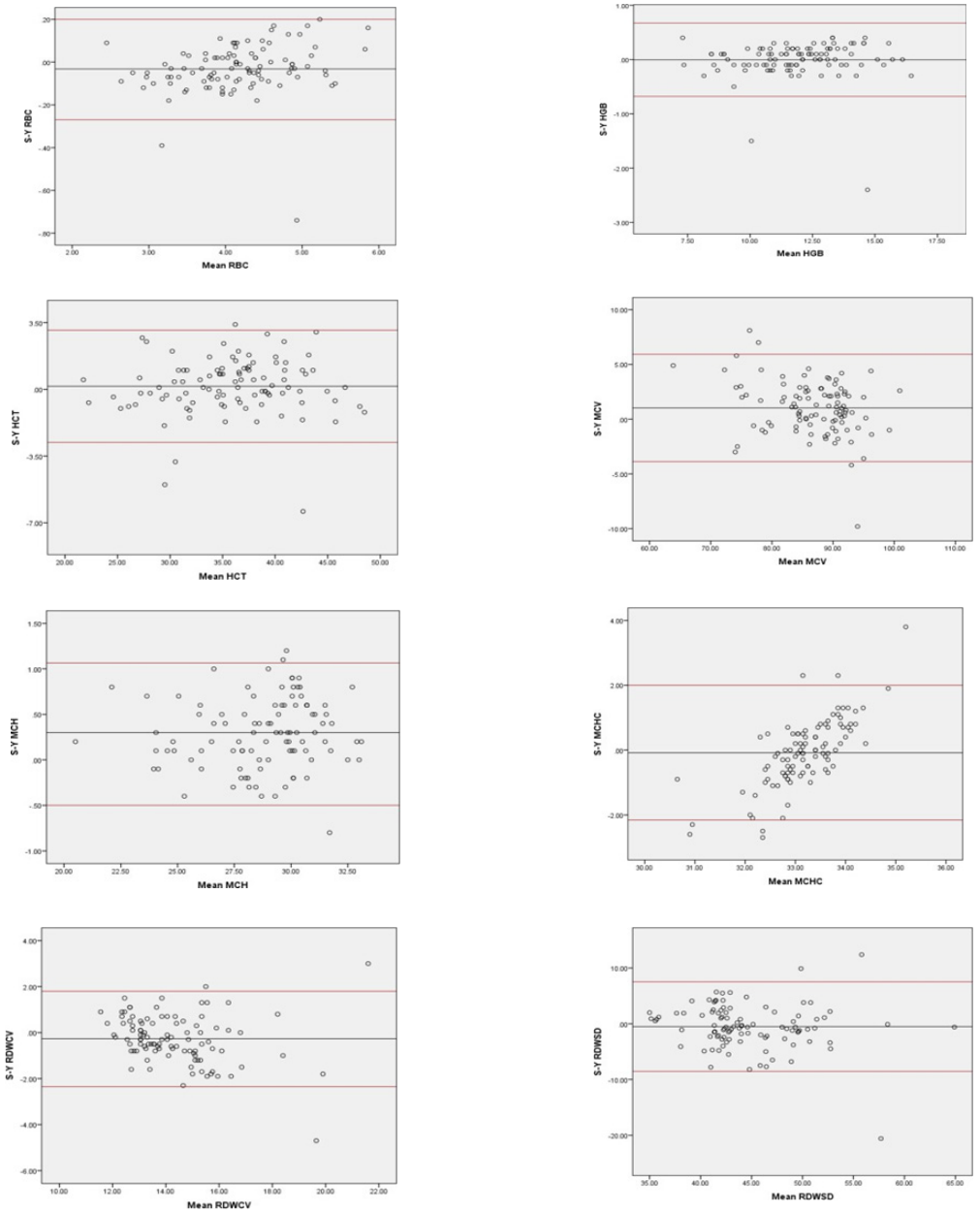

Figure 1. Bland-Altman plots for erythrocyte indices (i.e., RBC, HGB, HCT, MCV, MCH, MCHC, RDW-CV, RDW-SD)

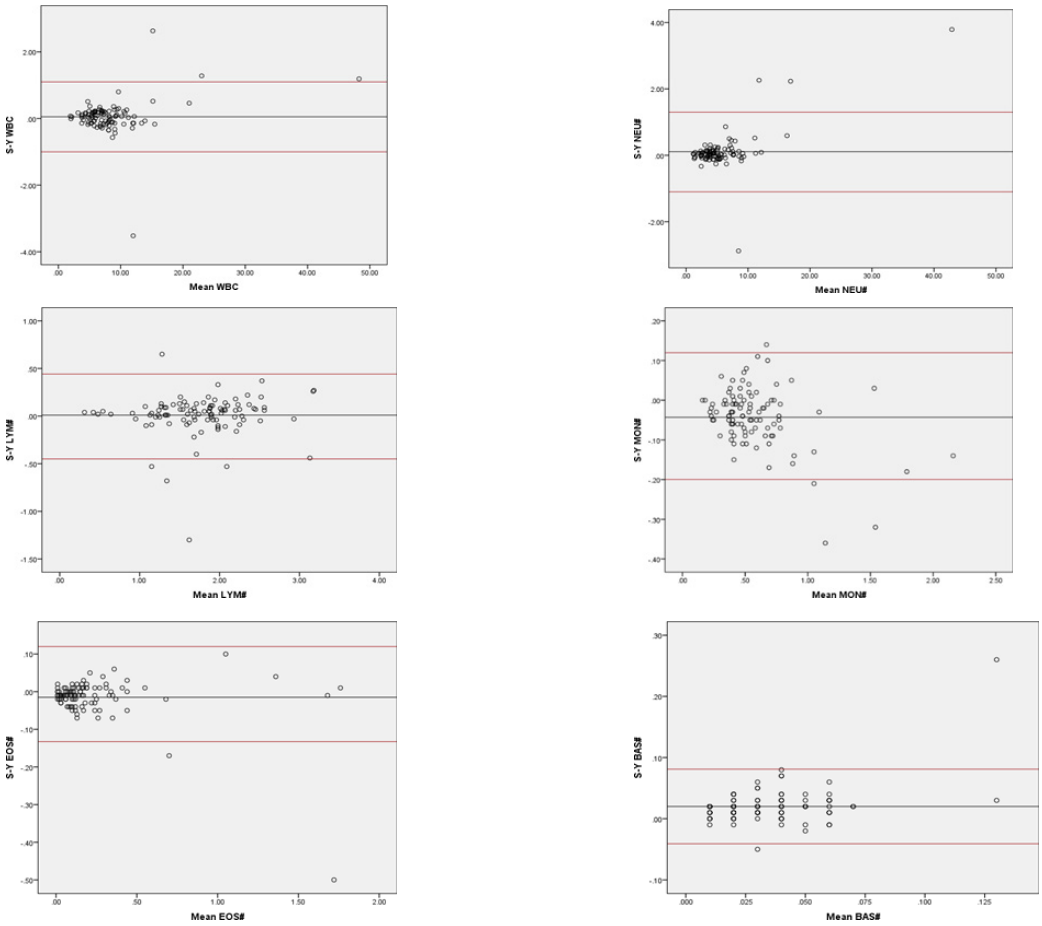

Figure 2. Bland-Altman plots for leukocyte indices (i.e., WBC, NEU, LYM, MON, EOS, BAS)

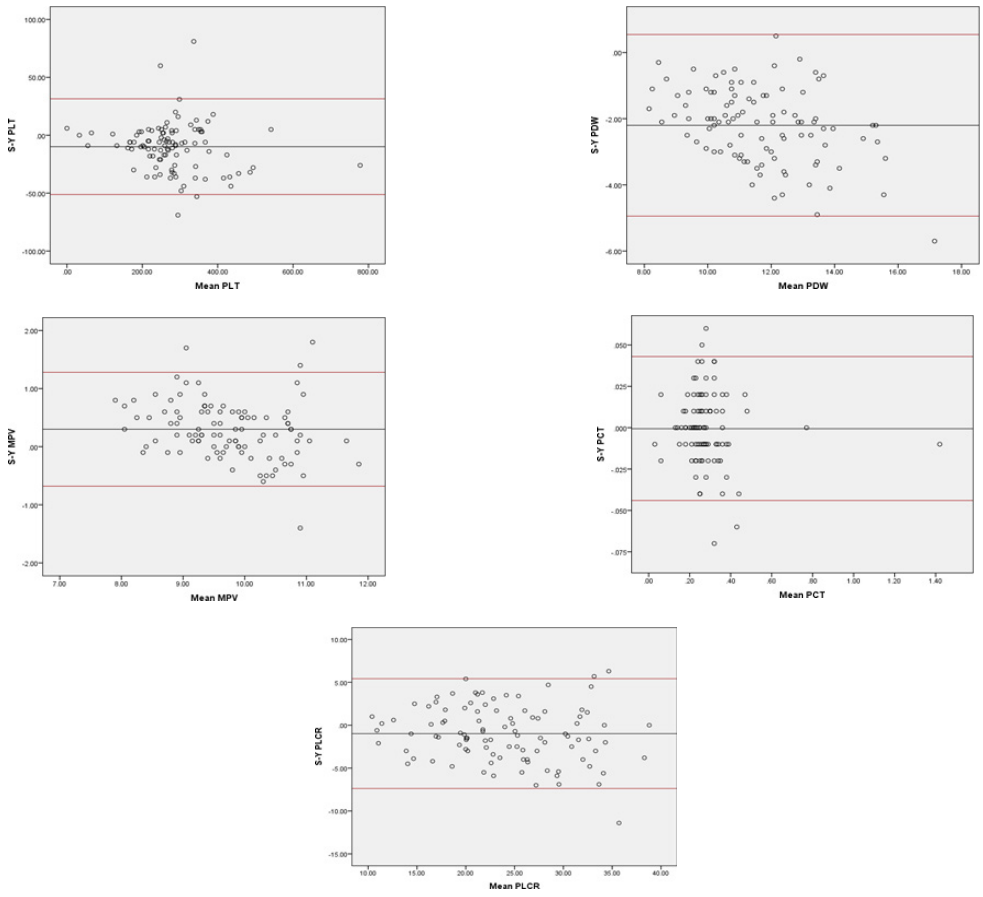

Figure 3. Bland-Altman plots for platelet indices (i.e., PLT, PDW, MPV, PCT, P-LCR)

Results of the correlation tests

Table 2 presents the average values of erythrocyte, leukocyte, and platelet indices measured using the Sysmex XN-3000 and Yumizen H2500, along with their correlations assessed by the Pearson and Spearman tests. The correlation tests indicated that all erythrocyte, leukocyte, and platelet indices confirmed significant correlations ($p<0.05$), with the correlation coefficients showing very strong agreement, except for MCHC, RDW-SD, and basophils that exhibited moderate to strong correlations. Among the parameters, WBC had the strongest correlation, whereas MCHC displayed the weakest correlation strength among all parameters.

Results of the Bland-Altman plot analysis

Figure 1 shows the Bland-Altman plots for erythrocyte indices. All parameters, with the exception of MCHC, exhibited fewer than five outliers outside the limits of agreement (LoA). The MCHC parameter revealed that seven outliers were identified beyond the established lower and upper limits, which were 2 and -2.16, respectively.

Figure 2 presents the Bland-Altman plots for leukocyte indices, indicating that all parameters had fewer than five outliers. The lower and upper limits for the WBC parameter were 1.1 and -0.1, respectively, with four outliers observed on the Bland-Altman plot. The NEU parameter had lower and upper limits of 1.3 and 1.1, respectively, with three outliers identified. The LYM parameter exhibited a lower limit of 0.441 and an upper limit of -0.43, along with five outliers. The MON parameter demonstrated a lower limit of -0.2 and an upper limit of 0.11, in addition to exhibiting four outliers. For the EOS parameter, the lower and upper limits were 0.64 and -0.88, respectively, with two outliers observed on the Bland-Altman plot. Finally, the BAS parameter had a lower limit of 0.08 and an upper limit of -0.04, with two outliers identified on the Bland-Altman plot.

Figure 3 illustrates the Bland-Altman plots for platelet indices. All parameters of the platelet indices exhibited fewer than five outliers. This was an indication that the measurements of platelet indices from both the Sysmex XN-3000 and Yumizen H2500 hematology analyzers were considered to be in agreement.

DISCUSSION

Comparison of erythrocyte indices

The statistical analysis using the Spearman test showed that the comparison of erythrocyte indices measured using the Sysmex XN-3000 and Yumizen H2500 hematology analyzers demonstrated a significant correlation. However, MCHC exhibited a weaker correlation strength compared to the other parameters. Figure 1 shows that the Bland-Altman plot indicated a lower level of agreement for the MCHC parameter, with the number of outliers exceeding the limit of agreement (LoA). The LoA was calculated using the formula for the mean difference between two variables ± (1.96 × standard deviation), resulting in the lower and upper limits as presented in Table 2. The results are considered comparable if 95% of the measurement outcomes fall within the mean difference range of ±1.96 standard deviations. In this study, there were 100 samples, allowing for a tolerable outlier threshold of 5%, equivalent to five outliers per parameter measurement (Giavarina, 2015).

The findings of this study are in line with those of prior research conducted by Pusparini & Alvina (2022), who utilized the Dymind DH-76 and Sysmex XN-1000 hematology analyzers. The study revealed a significant difference in the MCHC parameter according to the Bland-Altman regression plots and Passing-Bablok analysis. The differences in cell counting methods between the Sysmex XN-3000 and Yumizen H2500 likely contributed to the observed discrepancies.

As previously mentioned, the Sysmex XN-3000 and Yumizen H2500 hematology analyzers employ different methods for measuring erythrocytes and hemoglobin levels. The Sysmex XN-3000 analyzer uses hydrodynamic focusing to measure RBC and a cyanide-free sodium lauryl sulphate (SLS) method for hemoglobin quantification. In contrast, the Yumizen H2500 analyzer utilizes the impedance method and MCHC calculation. However, unlike this study, Ciepiela et al. (2016) reported differing results regarding the correlation of erythrocyte counts measured using the Dymind DH-76 and Sysmex XN-1000 hematology analyzers, highlighting limitations in agreement for the RDW parameter.

Comparison of leukocyte indices

In this study, the differences in leukocyte indices were analyzed using the Spearman test, demonstrating that all of the variables were correlated. Furthermore, all parameters exhibited significance values below 0.05. The leukocyte indices demonstrated a very strong correlation, with the exception of basophils, which exhibited a moderate correlation strength. As shown in the Bland-Altman plot, all leukocyte parameters had fewer than five outliers, indicating that the measurements from both analyzers were comparable. These findings align with an earlier study conducted by Bhola et al. (2024), who utilized the Sysmex XN-3000 and Yumizen H2500 hematology analyzers. Their study reported that the results of basophil measurements indicated a high bias.

The previous study conducted by Pusparini & Alvina (2022) on the Dymind DH-76 and Sysmex XN-1000 hematology analyzers discovered that the low correlation strength for basophils could be due to two possible factors: differences in differential count methods between the two instruments or the low quantity of basophils circulating in peripheral blood. In a separate study carried out by Lippi et al. (2014), a high correlation was found between basophil parameters measured using the BC-6800 hematology analyzer and manual microscopy.

Comparison of platelet indices

The Spearman test performed in this study revealed significant correlations for all platelet parameters, as represented by p-values less than 0.05. Additionally, all of the analyzed parameters exhibited correlation coefficient values above 0.8, signifying a very strong (nearly perfect) correlation. The Bland-Altman plots exhibited fewer than five outliers for all parameters, which indicated that the measurements were still considered comparable. The findings of this study align with those of a study reported by Bhola et al. (2024), outlining strong correlations across all platelet parameters. However, other studies have reported contrasting results, including one conducted by Małecka & Ciepiela (2020). In their research, a low correlation and significant differences in the PDW parameter were identified, which might be attributable to methodological differences between the two instruments used.

This study presents findings that focus on the validity of using two different hematology analyzers in medical laboratories, which may influence diagnostic outcomes,

disease management, and therapy monitoring. However, this study might be limited by the examination of blood samples occurring more than two hours after post-collection and their storage at room temperature. As outlined by Utami et al. (2019), prolonged storage at room temperature can cause a series of changes in blood cellular components, such as erythrocyte lysis and leukocyte destruction, which may affect the test results. This limitation highlights the importance of ensuring that blood analyses are conducted immediately after sample collection to maintain result accuracy.

CONCLUSION

The examinations of erythrocyte, leukocyte, and platelet indices using the Sysmex XN-3000 and Yumizen H2500 demonstrate significant correlations, indicating that both instruments are suitable for routine use. However, caution is needed when interpreting mean corpuscular hemoglobin concentration (MCHC) examination results due to their limited level of agreement. Future research is expected to identify the underlying causes of variations in MCHC examination results and explore methods to optimize compatibility between different hematology analyzers.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to the publication of this article.

ETHICS CONSIDERATION

This study passed the ethical review by the Health Research Ethics Committee of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, on November 20, 2023, as documented in protocol number 0836/KEPK/XI/2023.

FUNDING DISCLOSURE

This study received no financial support.

AUTHOR CONTRIBUTION

YPW contributed to the conception and design of the study, analysis and interpretation of the data, drafting of the article, provision of research materials or patients, statistical analysis, administrative and technical support, and data collection and assembly. YNI and PNAA contributed to the conception and design of the study, critical revision of the article for important intellectual content, final approval of the article, administrative support, as well as data collection and assembly. MRF contributed to the critical revision of the article for important intellectual content, statistical expertise, and final approval of the article.

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