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Original Research Article

Reference intervals and 24-hour temporal stability of 82 hematological parameters, including research-use-only parameters, on the Mindray BC-780 analyser in adults from Gujarat, Western India

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ABSTRACT

Background: The advent of advanced hematology analysers, such as the Mindray BC-780, has expanded the range of routinely reported and research-use-only (RUO) parameters, necessitating the need for accurate, population-specific reference intervals (RIs). This study aimed to define age- and gender-specific RIs for 82 parameters in a healthy adult population from Gujarat, western India, and to assess their temporal stability at room temperature (RT).
Methods: A cross-sectional study was conducted involving 1,376 healthy adults aged 18-94 years. Parameters were stratified by age and gender, and RIs were established using appropriate statistical methods, following CLSI guidelines. Temporal stability was evaluated by analysing samples at baseline (immediately after collection) and after storage at RT for 4, 8, 12, and 24 hours.
Results: Most parameters were non-normally distributed. Precision analysis revealed excellent reproducibility in 75 parameters. Stability testing showed 72 parameters remained stable over 24 hours at RT. Significant age- and gender-based differences were found in 47 parameters, requiring subgroup-specific reference intervals. RBC, HGB, and HCT decreased with age, while MCV and macro% increased; females showed lower RBC and HGB but higher PLT and PDW. Comparison with national and international studies demonstrated variation in a few parameters, emphasising the need for localised RIs.
Conclusions: This study establishes comprehensive, population-specific RIs for routine and RUO hematology parameters and confirms the temporal stability of most parameters at RT. The findings support the adoption of region-specific RIs to enhance diagnostic accuracy and clinical decision-making.

Keywords: Cell population data, Complete blood count, Hematology analyser, Reference intervals, Research-use-only parameters, Temporal stability

INTRODUCTION

The complete blood count (CBC) is one of the most frequently ordered clinical laboratory investigations, often considered a non-invasive "biopsy" due to its extensive diagnostic utility. Historically, early hematology analysers were limited to generating basic cell counts.[1] However, modern hematology analysers have advanced considerably, now offering a wide array of both routine and research-use-only (RUO) parameters, many of which show strong associations with specific diseases and underlying pathophysiological conditions.[2] This technological evolution necessitates accurate, population-specific reference intervals (RIs) for these expanded parameters to ensure valid clinical interpretation.[3]

While RIs for traditional parameters are well-documented in textbooks and scientific literature, data on novel RUO parameters remain sparse, making it challenging to utilise these values in diverse clinical settings. Establishing RIs for these new metrics on advanced analysers, such as the Mindray BC-780, is essential to enhance diagnostic precision.[4] Another critical aspect of hematological testing is the temporal stability of parameters, which ensures their reliability in routine practice. Although the stability of conventional hematology parameters at various storage conditions has been extensively investigated, limited research exists on the recently introduced RUO parameters.[5]

This study, therefore, had two primary objectives. First, to define age- and gender-specific RIs for 30 routine and 52 RUO hematological parameters generated by the Mindray BC-780 analyser in a healthy adult population from Gujarat, Western India. Second, to evaluate the temporal stability of all 82 parameters over 24 hours at RT. Regional studies are vital as hematological parameters vary considerably with genetic, environmental, and lifestyle factors. The findings of the present study aimed to address a critical gap in hematology diagnostics by providing a comprehensive, locally relevant reference database and essential pre-analytical stability evidence.

METHODS

This prospective, cross-sectional study was conducted between January 2025 and November 2025 at the Sterling Accuris Reference Laboratory, Surat, India. Clinically healthy adults (aged 18-94 years) undergoing comprehensive annual health check-ups were enrolled. Participants were classified as healthy based on clinical evaluation and laboratory screening. Individuals with evidence of acute or chronic illness, pregnancy, hypertension, malignancy, hematological disease, infection, inflammatory conditions, or other clinically apparent disorders were excluded. Routine biochemical and immunological investigations, including liver and renal function tests, blood glucose, thyroid profile, vitamin B12, iron studies, CRP, HIV, and HBsAg, were within normal reference ranges in all included participants. A total of 1,376 participants (785 males, 591 females) were enrolled. The study protocol adhered to the Clinical and Laboratory Standards Institute (CLSI) C28-A3 guidelines for reference interval determination, including outlier detection and ensuring a minimum of 120 individuals per age- and gender-specific subgroup. All blood samples were screened for pre-analytical variables, including inappropriate blood-to-anticoagulant ratio, haemolysis, clots, and prolonged time between collection and analysis.

Sample collection and analysis

Blood samples were collected into K_2EDTA Vacutainer tubes (Becton, Dickinson and Company, NJ, USA) and analysed immediately in CD mode using the Mindray BC-780 automated hematology analyser (Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China). The analyser reports a total of 82 parameters: 30 routine and 52 RUO parameters. A complete list of parameters, their descriptions and units are provided in Appendix 1.

Precision analysis

To assess preliminary within-run precision, a single representative blood sample was analysed 10 consecutive times under identical analytical conditions. The coefficient of variation (CV%) was calculated for each parameter to estimate analytical reproducibility.

Temporal stability analysis

To evaluate parameter stability, 25 randomly selected samples were analysed immediately after collection (0 hour, baseline) and subsequently after storage at room temperature (22-26°C) for 4, 8, 12, and 24 hours. A deviation exceeding 10% from the baseline value at any time point was considered clinically significant, indicating instability.

Statistical analysis

Statistical analyses were performed using Microsoft Excel, SPSS, and a custom Python-based program. Data were stratified by gender (male, female) and by age group (18-39 years, 40-59 years, and ≥60 years).

The normality of distribution for each parameter was assessed using the Shapiro-Wilk test. For gender-based comparisons, the independent samples t-test was used for normally distributed data and the Mann-Whitney U test for non-normally distributed data. For age-based comparisons across three groups, one-way ANOVA with Tukey's post-hoc test was used for normally distributed data with homogeneous variances (confirmed by Levene's test). The Kruskal-Wallis test with Dunn's post-hoc test and Bonferroni correction was used for non-normally distributed data or when variances were unequal.

Reference interval determination

For parameters with no statistically significant differences between age or gender subgroups, common reference intervals (RIs) were calculated using the parametric mean ±2SD for normally distributed data or the non-parametric 2.5^{th}-97.5^{th} percentile for non-normally distributed data. For parameters showing significant subgroup differences, separate, subgroup-specific RIs were derived using the same respective methods.

Correlation analysis

Inter-parameter correlations were evaluated using a correlogram. Correlation strength was categorized based on the absolute value of the correlation coefficient (r) as strong ($|r|>0.7$), moderate ($0.5<|r|\leq0.7$), weak ($0.3<|r|\leq0.5$), or negligible ($|r|\leq0.3$). Positive and negative

values of r indicated positive and inverse correlations, respectively.

Quality assurance

Internal quality control (IQC) was performed daily using three commercially available levels (low, normal, and high), and results were monitored per standard operating procedures (SOPs). External proficiency testing was also conducted to ensure method accuracy and reliability.

RESULTS

A total of 1,376 healthy adults (785 males, 591 females) were enrolled and stratified into three age groups: 18-39 years, 40-59 years, and ≥60 years. The study analysed 82 parameters (30 routine and 52 RUO), which are described in Table 1.

Data distribution and parameters excluded

The Shapiro-Wilk test revealed that most parameters had non-normal distributions ($p<0.05$). Parameters that were normally distributed included Neu%, Lym%, Neu%&, Lym%&, Neu-Y, Neu-Z, Lym-Z, and Mon-Y. Several parameters consistently showed values of zero (NRBC#, NRBC%, InR#, InR‰, SRBC, LRBC, SMCV, and LMCV) and were excluded from further analysis (Table 1).

Table 1: Shapiro-Wilk test, reference interval, precision (CV%), and temporal stability for entire data set.

Parameters	Shapiro-Wilk test P value	Median	Mean (SD)	RI	Precision CV%	Temporal Stability
WBC	<0.05	7.14	7.42 (2.01)	4.31-12.01	1.2	24 Hours
Neu#	<0.05	4.44	4.75 (1.64)	2.28-8.56	1.5	24 Hours
Lym#	<0.05	2.37	2.44 (0.68)	1.27-4.03	2.7	24 Hours
Mon#	<0.05	0.44	0.46 (0.14)	0.25-0.8	4.2	24 Hours
Eos#	<0.05	0.2	0.24 (0.15)	0.05-0.6	8.1	24 Hours
Bas#	<0.05	0.02	0.03 (0.02)	0-0.07	9.9	24 Hours
IMG#	<0.05	0.01	0.02 (0.02)	0-0.1	10.8	8 Hours
Neu%	0.24	58.8	59.03 (8.35)	42.33-75.73	1.2	24 Hours
Lym%	0.29	31.8	31.59 (7.61)	16.37-46.81	2.1	24 Hours
Mon%	<0.05	5.6	5.96 (1.61)	3.8-9.9	3.7	24 Hours
Eos%	<0.05	2.7	3.07 (1.82)	0.7-7.76	6.5	24 Hours
Bas%	<0.05	0.3	0.35 (0.26)	0-0.9	9.3	24 Hours
IMG%	<0.05	0.2	0.27 (0.27)	0-1	10.2	8 Hours
RBC	<0.05	4.79	4.8 (0.51)	3.85-5.82	0.6	24 Hours
HGB	<0.05	13.4	13.47 (1.53)	10.54-16.5	0.3	24 Hours
HCT	<0.05	41.9	41.97 (4.49)	33.84-50.7	0.6	24 Hours
MCV	<0.05	87.95	87.63 (5.19)	77-97.76	0.2	24 Hours
MCH	<0.05	28.3	28.13 (2.05)	23.54-31.8	0.6	24 Hours
MCHC	<0.05	32.1	32.08 (0.86)	30.2-33.76	0.3	24 Hours
RDW-CV	<0.05	13.5	13.71 (1.05)	12.3-16.46	0.2	24 Hours
RDW-SD	<0.05	42.4	42.95 (3.17)	38.24-51.12	0.6	24 Hours
PLT	<0.05	289	298.12 (73.96)	177-473.38	3.3	24 Hours
MPV	<0.05	9	9.13 (1.11)	7.5-11.76	2.7	24 Hours
PDW	<0.05	16.1	16.13 (0.37)	15.5-16.9	1.2	24 Hours
PCT	<0.05	0.26	0.27 (0.06)	0.17-0.41	3.9	24 Hours
P-LCC	<0.05	57	60.3 (19.65)	30-106.62	6	24 Hours
P-LCR	<0.05	19.8	20.96 (7.43)	10.2-38.8	4.8	24 Hours
IPF	<0.05	1.2	1.53 (1.16)	0.5-4.5	6.3	24 Hours
NRBC#	1	0	0 (0)	0-0	0	24 Hours
NRBC%	1	0	0 (0)	0-0	0	24 Hours
HFC#	<0.05	0.01	0.01 (0.02)	0-0.06	12.6	24 Hours
HFC%	<0.05	0.1	0.19 (0.32)	0-0.8	9.9	24 Hours
WBC-D	<0.05	7.64	7.91 (2)	4.81-12.56	1.2	24 Hours
TNC-D	<0.05	7.64	7.91 (2)	4.81-12.56	1.2	24 Hours
IME%	<0.05	0	0 (0.02)	0-0.1	0	24 Hours
IME#	<0.05	0	0 (0)	0-0	0	24 Hours
NLR	<0.05	1.85	2.08 (0.96)	0.91-4.55	4.2	24 Hours
InR#	1	0	0 (0)	0-0	0	24 Hours
InR‰	1	0	0 (0)	0-0	0	24 Hours
Neu#&	<0.05	4.43	4.72 (1.62)	2.28-8.49	1.5	24 Hours

Continued.

Parameters	Shapiro-Wilk test P value	Median	Mean (SD)	RI	Precision CV%	Temporal Stability
Neu%&	0.29	58.5	58.75 (8.35)	42.05-75.45	0.6	24 Hours
Lym#&	<0.05	2.36	2.43 (0.68)	1.25-3.99	3	24 Hours
Lym%&	0.33	31.6	31.41 (7.57)	16.27-46.55	2.4	24 Hours
Micro#	<0.05	0.05	0.09 (0.1)	0.02-0.39	5.1	24 Hours
Micro%	<0.05	1.1	1.76 (2)	0.4-7.7	5.7	24 Hours
Macro#	<0.05	0.14	0.15 (0.05)	0.07-0.25	5.5	8 Hours
Macro%	<0.05	2.9	3.06 (0.99)	1.6-5.4	5.4	8 Hours
H-IPF	<0.05	0.4	0.51 (0.43)	0.2-1.56	8.7	24 Hours
IPF#	<0.05	4	4.28 (2.62)	01-Nov	7.2	24 Hours
PLT-I	<0.05	287	296.23 (74.23)	174-471.38	3.4	24 Hours
PLR	<0.05	123.75	129.91 (45.27)	68.12-234.11	3.6	24 Hours
PDW-SD	<0.05	10.35	10.74 (2.25)	7.9-16.2	4.3	24 Hours
SRBC	1	0	0 (0)	0-0	0	24 Hours
LRBC	1	0	0 (0)	0-0	0	24 Hours
SMCV	1	0	0 (0)	0-0	0	24 Hours
LMCV	1	0	0 (0)	0-0	0	24 Hours
Neu-X	<0.05	364	364.8 (21.31)	325.29-408.92	1.7	24 Hours
Neu-Y	0.74	491.7	492.59 (28.3)	435.99-549.19	1.7	24 Hours
Neu-Z	0.31	1753.5	1753.35 (57.48)	1638.39-1868.31	3.2	24 Hours
Lym-X	<0.05	127.6	127.96 (4.8)	119.1-137.5	1.9	24 Hours
Lym-Y	<0.05	916.45	922.3 (40.21)	847.98-1012.26	2	24 Hours
Lym-Z	0.14	1154.15	1154.34 (18.98)	1116.38-1192.3	2.4	24 Hours
Mon-X	<0.05	260.15	260.6 (8.99)	245.14-278.32	1.6	24 Hours
Mon-Y	0.16	1256.05	1257.4 (53.39)	1150.62-1364.18	3.1	24 Hours
Mon-Z	<0.05	1429.3	1430.45 (33.09)	1373.05-1499.05	1.5	24 Hours
Neu-XW	<0.05	223.6	224.58 (15.81)	196.2-258.16	6.4	8 Hours
Neu-YW	<0.05	223	223.36 (10.95)	202.68-245.26	4.8	24 Hours
Neu-ZW	<0.05	520.7	521.49 (19.38)	484.88-564.6	6.6	8 Hours
Lym-XW	<0.05	60.6	60.77 (3.53)	54.7-68.66	5.2	24 Hours
Lym-YW	<0.05	455.2	456.43 (39.67)	383.04-540.5	4.6	24 Hours
Lym-ZW	<0.05	299.45	300.74 (12.53)	278.84-327.16	3.5	24 Hours
Mon-XW	<0.05	90.2	90.66 (6.41)	78.9-103.76	7.1	24 Hours
Mon-YW	<0.05	542.7	545.95 (46.4)	462.26-648.01	5.3	24 Hours
Mon-ZW	<0.05	384.8	387.9 (29.07)	341.48-453.49	8.7	8 Hours
PLT-H	<0.05	289	298.11 (73.99)	177-473.38	3.3	24 Hours
IPF-D	<0.05	1.2	1.53 (1.16)	0.5-4.5	6.3	24 Hours
RET%-D	<0.05	1.14	1.23 (0.57)	0.4-2.54	7.2	24 Hours
RET#-D	<0.05	0.05	0.06 (0.03)	0.02-0.12	9.6	24 Hours
IRF-D	<0.05	11.6	12.62 (6.24)	4-28.1	7.2	4 Hours
LFR-D	<0.05	88.4	87.38 (6.24)	71.9-96	5.4	24 Hours
MFR-D	<0.05	10.2	10.71 (4.55)	3.64-21.06	9.2	4 Hours
HFR-D	<0.05	1.3	1.91 (1.89)	0.3-7.2	8.7	4 Hours

RI = Reference interval; SD = Standard deviation; CV = Coefficient of variation; p<0.05 indicates a statistically significant deviation from normality; p≥0.05 indicates no statistically significant deviation from normality. % - Percent; # - Absolute count; %- Permillage.

Precision (reproducibility)

Among the 30 routine parameters, 22 had a coefficient of variation (CV) of <5%. Red cell parameters showed excellent reproducibility (CV<1%). Higher variability (CV>5%) was observed in some white blood cell-related parameters, like eosinophil, basophil, and immature granulocyte parameters. Among platelet parameters, all had CV <5% except P-LCC and IPF.

Of the 52 RUO parameters, 31 had CV <5%, 20 had CV between 5-10%, and only one parameter exceeded a CV of 10% (Table 1).

Temporal stability at room temperature

After 24 hours of storage at room temperature (RT), 28 of 30 routine parameters and 44 of 52 RUO parameters remained stable (deviation <10% from baseline). Parameters with limited stability included:

Among the routine parameters, those related to immature granulocytes (IMG# and IMG%) were stable for up to 8 hours. Among the RUO parameters, Macro#, Macro%, Neu-XW, Neu-ZW, and Mon-ZW remained stable for up to 8 hours, whereas some reticulocyte-related parameters such as IRF-D, LFR-D, and MFR-D, were stable for only up to 4 hours (Table 1 and Figure 1).

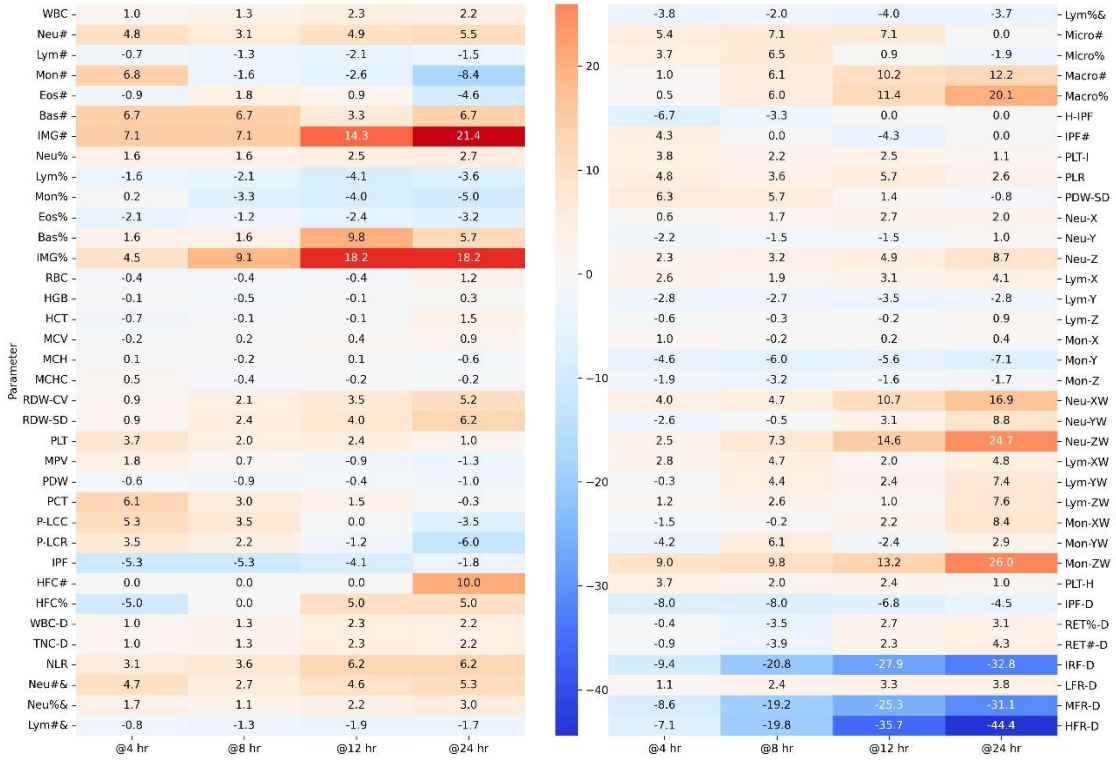

Figure 1: % change in parameters from baseline (0 hour) result.

Table 2: Stratified reference interval.

Parameters	Stratification	Male (n=785) 18-39 years n=245	40-59 years n=397	>59 years n=143	Female (n=591) 18-39 years n=187	40-59 years n=267	>59 years n=137
WBC	(A<0.05) (G<0.001)	4.4-11.4	4.33-11.75	4.07-12.42	4.64-12.02	4.4-12.33	5.17-12.14
Neu#	(A<0.001) (G<0.001)	2.13-8.28	2.29-8.29	2.18-9.1	2.56-8.68	2.26-8.95	2.71-8.31
Lym#	(G<0.001)	1.25-3.85			1.35-4.17		
Mon#	(A<0.05) (G<0.001)	0.27-0.74	0.27-0.8	0.3-0.97	0.23-0.71	0.24-0.79	0.28-0.73
Eos#	(G<0.001)	0.06-0.61			0.05-0.6		
Bas#	NO	0-0.07					
IMG#	NO	0-0.1					
Neu%	(A<0.05) (G<0.001)	39.63-75.09	41.86-74.23	43.56-78.02	46.51-76.91	42.94-75.34	43.33-75.46
Lym%	(A<0.05)	16.59-46.76(1) / 16.96-46.93(2) / 15.6-45.2(3)					
Mon%	(A<0.05) (G<0.001)	4.1-10.4	4.2-10.33	4.46-10.96	3.26-7.94	3.7-8.5	3.88-9.3
Eos%	(G<0.001)	0.8-8.2			0.6-7.12		
Bas%	NO	0-0.9					
IMG%	(G<0.05)	0-1.1			0-0.9		
RBC	(A<0.001) (G<0.001)	4.36-5.97	4.13-5.94	4.04-5.64	3.74-5.17	3.7-5.32	3.6-5.33
HGB	(A<0.001) (G<0.001)	12.46-16.72	11.6-16.7	11.08-16.57	10.14-14.22	10.36-14.47	10.1-14.64
HCT	(A<0.001) (G<0.001)	38.86-51.47	36.99-51.8	34.7-51.34	32.29-43.95	32.96-45	32.05-45.62
MCV	(A<0.05) (G<0.001)	78-97.7	76.99-100.6	80.72-96.97	77.2-94.81	74.76-96.24	76.8-97.69
MCH	(G<0.001)	23.86-32.4			23.28-30.92		
MCHC	(A<0.05) (G<0.001)	30.6-33.8	30.3-33.9	30.38-33.91	30.02-33.86	30.1-33.3	30.08-33.72
RDW-CV	(G<0.05)	12.3-15.9			12.3-17.02		
RDW-SD	(A<0.001) (G<0.05)	37.2-51	38.9-51.68	39.76-49.1	38.5-51.62	37.8-50.14	37.84-50.66
PLT	(A<0.001) (G<0.001)	197-429	173.6-412.1	166.75-418	197.62-505.38	199.2-485.4	187.4-544.6
MPV	NO	7.5-11.76					
PDW	(G<0.001)	15.5-16.9			15.5-16.8		
PCT	(A<0.001) (G<0.001)	0.18-0.38	0.16-0.36	0.15-0.35	0.2-0.44	0.2-0.43	0.17-0.46
P-LCC	(G<0.001)	28-98			36-112.25		
P-LCR	NO	10.2-38.8					

Continued.

Parameters	Stratification	Male (n=785) 18-39 years n=245	40-59 years n=397	>59 years n=143	Female (n=591) 18-39 years n=187	40-59 years n=267	>59 years n=137
IPF	(A<0.001)	0.5-3.73(1) / 0.5-4.6(2) / 0.5-5.3(3)					
NRBC#	NO	0-0					
NRBC%	NO	0-0					
HFC#	(A<0.05) (G<0.001)	0-0.05	0-0.04	0-0.06	0-0.06	0-0.05	0-0.09
HFC%	(G<0.05)	0-0.7			0-0.8		
WBC-D	(A<0.05) (G<0.001)	4.9-11.9	4.83-12.25	4.57-12.86	5.14-12.52	4.8-12.83	5.67-12.64
TNC-D	(A<0.05) (G<0.001)	4.9-11.9	4.83-12.25	4.57-12.86	5.14-12.52	4.8-12.83	5.67-12.64
IME%	NO	0-0.1					
IME#	NO	0-0					
NLR	(A<0.05)	0.92-4.21(1) / 0.91-4.56(2) / 0.94-4.62(3)					
InR#	NO	0-0					
InR‰	NO	0-0					
Neu#&	(A<0.001) (G<0.001)	2.12-8.25	2.29-8.24	2.17-8.97	2.56-8.66	2.26-8.91	2.7-8.27
Neu%&	(A<0.05) (G<0.001)	39.3-74.81	41.55-73.97	43.28-77.65	46.36-76.6	42.7-75.05	43.06-75.19
Lym#&	(G<0.001)	1.24-3.84			1.3-4.12		
Lym%&	(A<0.05)	16.44-46.54(1) / 16.87-46.69(2) / 15.4-45.1(3)					
Micro#	(G<0.05)	0.02-0.33			0.02-0.42		
Micro%	(G<0.001)	0.3-5.9			0.4-8.52		
Macro#	(G<0.001)	0.09-0.29			0.07-0.19		
Macro%	(G<0.001)	1.8-6.4			1.58-4.6		
H-IPF	(A<0.001) (G<0.05)	0.2-1.2	0.2-1.91	0.2-2.01	0.1-1.27	0.2-1.33	0.2-1.72
IPF#	(G<0.001)	1-11.4			2-11		
PLT-I	(A<0.001) (G<0.001)	196-427	166.8-410.1	166.2-416.45	191.5-503.38	198.2-483.4	187-542.6
PLR	(A<0.05) (G<0.001)	75.07-212.44	66.17-228.46	58.56-223.4	73.45-240.59	73.3-232.19	64.7-261.71
PDW-SD	NO	7.9-16.2					
SRBC	NO	0-0					
LRBC	NO	0-0					
SMCV	NO	0-0					
LMCV	NO	0-0					
Neu-X	(A<0.05)	323.88408.09(1) / 323.57-407.85(2) / 325.68-407.09(3)					
Neu-Y	NO	435.99-549.2					
Neu-Z	(G<0.05)	1636.87-1877.08			1641.44-1855.6		
Lym-X	(A<0.001) (G<0.001)	118.5-137.6	119.23-138.81	120.12-138.27	118.16-134.5	119.9-136.85	119.67-136.38
Lym-Y	(A<0.001)	856.26-1011.74(1) / 848.64-1015.83(2) / 836.86-997.72(3)					
Lym-Z	(A<0.05)	1119.7-1190.04(1) / 1117.42-1194.59(2) / 1116.72-1190.34(3)					
Mon-X	(G<0.05)	244-278.84			246.95-277.68		
Mon-Y	(A<0.05)	1164.55-1365.59(1) / 1150.75-1369.72(2) / 1148.82-1346.71(3)					
Mon-Z	NO	1373.05-1499.05					
Neu-XW	NO	196.2-258.16					
Neu-YW	(A<0.001) (G<0.05)	199.48-243.69	204.97-246.05	201.1-248.71	202.01-240.89	204.62-245.24	203.47-247.52
Neu-ZW	(A<0.05) (G<0.05)	482.2-571.3	486.72-564.66	480.89-564.53	478.81-553.23	493.22-555.33	485.68-559.54
Lym-XW	(A<0.05) (G<0.001)	53.13-67.42	54.49-68.53	53.9-68.4	55.86-67.1	56.36-69.65	54.78-68.88
Lym-YW	(A<0.001) (G<0.001)	402.5-533	377.69-539.99	364.1-525.86	402.45-532.25	396.04-554.7	369.99-540.41
Lym-ZW	NO	278.84-327.16					
Mon-XW	(G<0.05)	77.83-102.6			79.4-104.72		
Mon-YW	(G<0.001)	458.36-636.9			475.5-657.55		
Mon-ZW	NO	341.48-453.49					
PLT-H	(A<0.001) (G<0.001)	197-429	173.6-412.1	166.75-418	197.62-505.38	199.2-485.4	187.4-544.6
IPF-D	(A<0.001)	0.5-3.73(1) / 0.5-4.6(2) / 0.5-5.3(3)					
RET%-D	(G<0.001)	0.43-2.32			0.38-2.74		
RET#-D	NO	0.02-0.12					
IRF-D	(G<0.05)	3.76-27.44			4.2-28.22		
LFR-D	(G<0.05)	72.56-96.24			71.78-95.8		
MFR-D	NO	3.64-21.06					
HFR-D	(A<0.05) (G<0.001)	0.2-5.4	0.29-6.71	0.3-11.33	0.3-8.54	0.3-8.44	0.24-5.08

A = Age effect; G = Gender effect; NO = No partitioning required; $p<0.05$ and $p<0.001$ denote statistically significant differences; (1), (2), and (3) represent the age groups 18-39, 40-59, and >59 years, respectively.

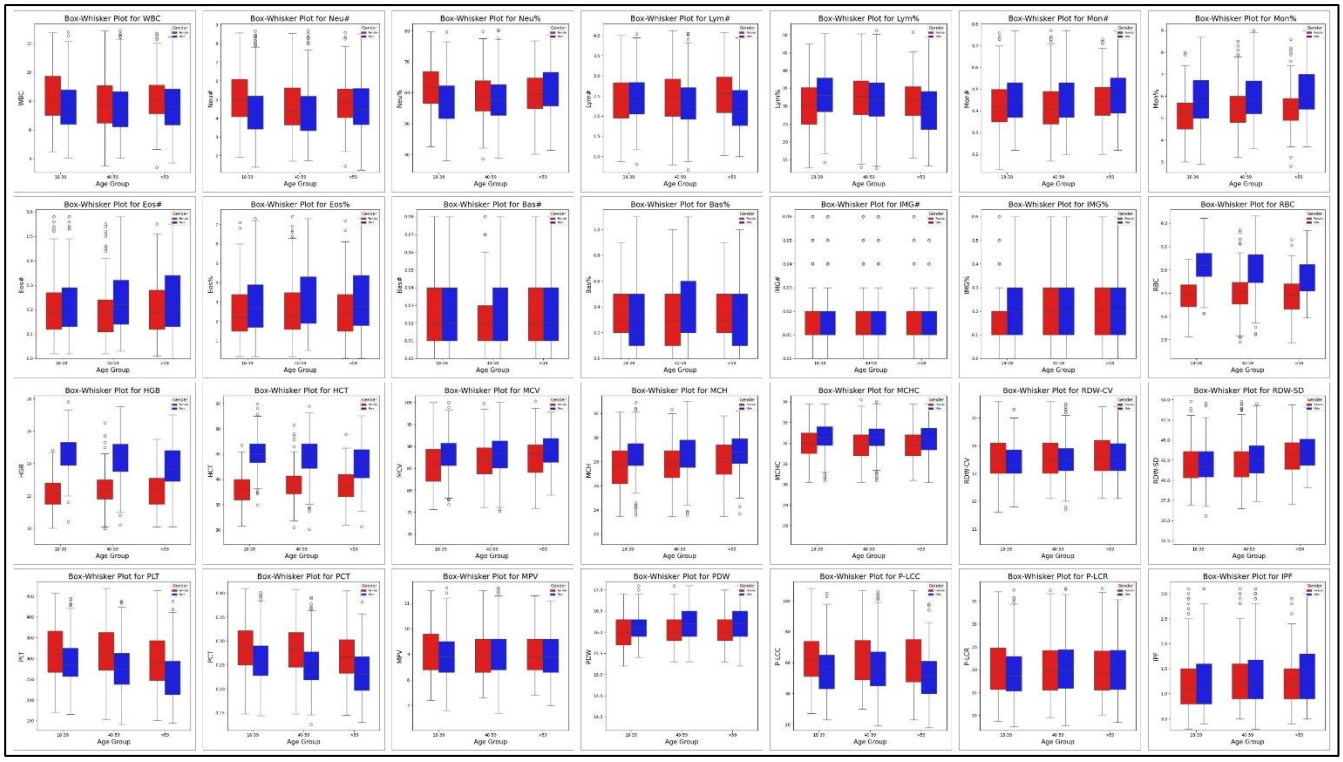

Figure 2: Age-wise and gender-wise trend of routine parameters.

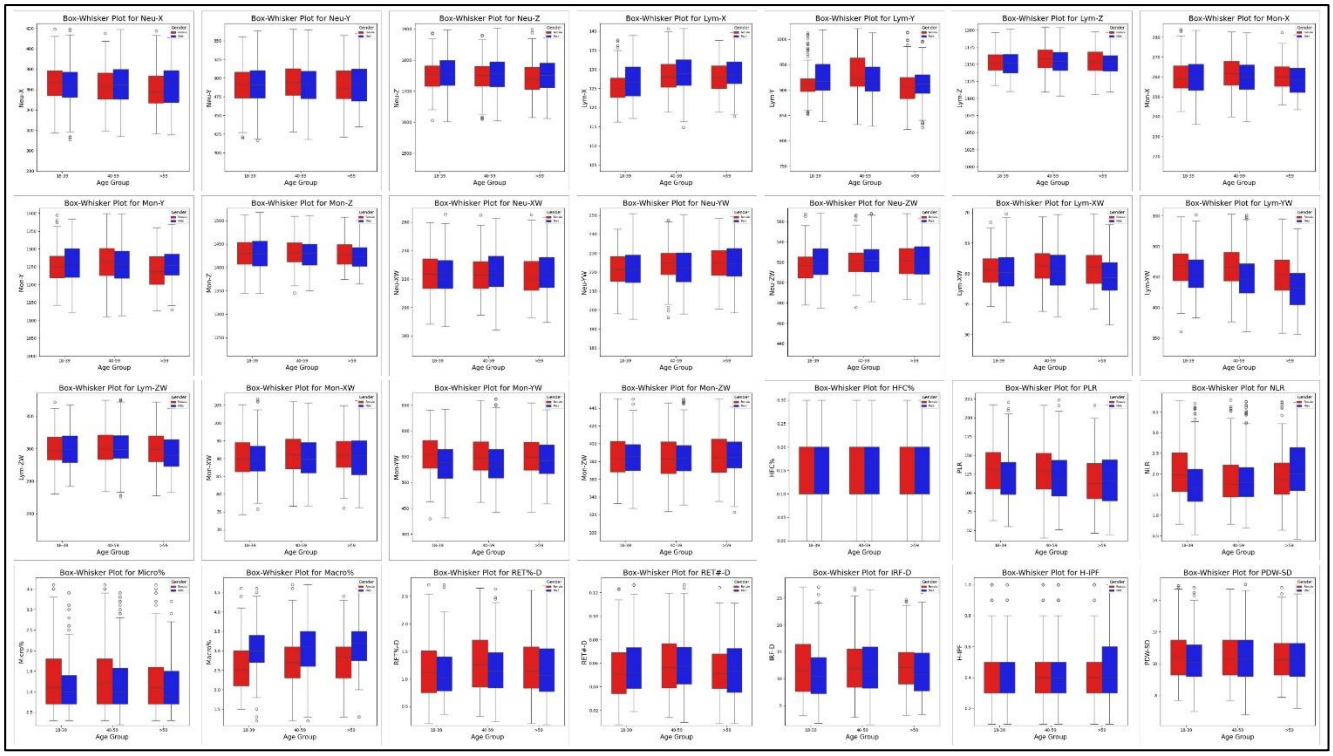

Figure 3: Age-wise and gender-wise trend of RUO parameters.

Subgroup differences and reference interval partitioning

Statistical comparisons identified parameters requiring age- and/or gender-specific reference intervals (RIs) (Table 2).

No significant differences (common RI): 7 routine parameters (Bas#, IMG#, Bas%, MPV, P-LCR, NRBC#, NRBC%) and 16 RUO parameters (IME%, IME#, InR#, InR‰, PDW-SD, SRBC, LRBC, SMCV, LMCV, Neu-Y,

Mon-Z, Neu-XW, Lym-ZW, Mon-ZW, RET#-D, MFR-D).

Age-specific only (9 parameters): Lym%, IPF, NLR, Lym%&, Neu-X, Lym-Y, Lym-Z, Mon-Y, and IPF-D.

Gender-specific only (22 parameters): Lym#, Eos#, Eos%, IMG%, MCH, RDW-CV, PDW, P-LCC, HFC%, Lym#&, Micro#, Micro%, Macro#, Macro%, IPF#, Neu-Z, Mon-X, Mon-XW, Mon-YW, RET%-D, IRF-D, LFR-D.

Both age and gender-specific (28 parameters): WBC, Neu#, Mon#, Neu%, Mon%, RBC, HGB, HCT, MCV, MCHC, RDW-SD, PLT, PCT, HFC#, WBC-D, TNC-D, Neu#&, Neu%&, H-IPF, PLT-I, PLR, Lym-X, Neu-YW, Neu-ZW, Lym-XW, Lym-YW, PLT-H, HFR-D (Table 2).

Age and gender trends in routine parameters

White blood cells: WBC, Neu#, and Neu% were higher in females. Lym# and Lym% declined with age in males. Monocyte counts were higher in males and increased with age in both genders. Eosinophils were higher in males across all ages, with a slight upward trend with age in males.

Red blood cells: RBC, HGB, and HCT were significantly higher in males. With advancing age, these parameters decreased in males but increased in females. MCV and MCH were higher in males and increased with age in both genders, while MCHC showed no significant age-related change. RDW-SD increased with age in both genders.

Platelets: PLT, PCT, and P-LCC were consistently higher in females and declined with advancing age. PDW and IPF were slightly higher in males (Figure 2).

Age and gender trends in RUO parameters

Leukocyte cell population data (CPD) showed minimal variation across age and gender, except for a slight decrease in neutrophil parameters (Neu-X, Neu-Y, Neu-Z) in older individuals. Most monocyte and lymphocyte CPD parameters peaked in middle-aged adults. Lymphocyte distribution widths (XW, YW, ZW) were generally higher in females. PLR and NLR were higher in females in the youngest age group, but became lower in females than in males in the oldest age group. Microcytic red cells (Micro%, Micro#) were more prevalent in females, while macrocytic red cells (Macro%, Macro#) were more frequent in males. Reticulocyte percentage (RET%-D) was higher in females (Figure 3).

Comparison with other populations

Comparison with national and international studies revealed notable variations. WBC and neutrophil counts in the present study cohort were comparable to Kuwaiti data but higher than Omani and Kenyan cohorts. Platelet counts were higher than those reported in Canadian, Kuwaiti, Omani, and Brazilian populations. Within India, comparisons showed higher WBC and neutrophil counts but lower eosinophil counts compared to eastern and southern Indian populations (Table 3).

Table 3: Comparison of parameters with different ethnic groups.

Parameters	Country	France[6]	Canada[7]	Kuwait[8]	Mali[9]	Oman[10]	Kenya[11]	Thai[12]	Brazil[13]	Saudi Arabia[14]	Indonesia[4]	India[15] (Eastern)	India[16] (Southern)	Present western-India
	Age Range (yrs)	20-59	20-79	18-96	18-59	18-69	20-65	18-60	18-59	18-55	>17	18-40	20-70	18-94
WBC	Male	4.09-11	3.8-10.4	5.9-12	2.97-8.80	2.79-8.09	3.13-8.10	4.5-11.3	2.8-9.4	3.3-11.2	3.99 - 9.69	4.28-10.16	4.0-10.4	4.23 - 11.93
	Female	4.02-11.42	3.8-10.4	5.4-11	3.8-12.5	2.79-8.09	2.89-7.72	4.4-10.3	2.9-10.04	3.1-11.2	5.42 - 8.42	4.38-10.50	4.2-9.8	4.39 - 12.21
Neu#	Male	1.78-6.94	1.8-7.2	2.7-8.0	1.0-4.4	0.91-4.61	1.02-3.92	1.8-7.9	0.55-5.9	1.2-8.8	2.28 - 5.78	2.25-6.4	(42-74%)	2.21 - 8.39
	Female	1.75-7.50	2.0-7.4	2.6-8.0	1.2-7.4	0.91-4.61	1.07-4.42	1.76-7.51	0.59-6.55	1.3-7.6	3.01 - 5.43	2.01-7.25	(44-75%)	2.47 - 8.86
Lym#	Male	1.34-3.91	1.0-3.2	1.5-3.0	1.2-3.8	1.12-3.15	1.36-3.58	1.3-3.5	0.76-3.40	1.16-3.6	1.41 - 2.99	1.10-3.8	(18-45%)	1.25 - 3.85
	Female	1.37-3.96	1.0-3.2	1.4-3.0	1.4-4.6	1.12-3.15	1.22-3.24	1.2-3.4	0.82-3.49	1.1-3.8	1.3 - 2.84	1.19-3.37	(18-45%)	1.35 - 4.17
Mon#	Male	0.22-0.77	0.2-0.8	0.4-1.0	0.1-0.67	0.23-0.72	0.15-0.76	0.2-0.9	0.01-0.81	0.2-0.7	0.2 - 0.58	0.23-0.72	(2-10%)	0.27 - 0.83
	Female	0.20-0.71	0.2-0.8	0.4-1.0	0.1-0.5	0.23-0.72	0.14-0.68	0.2-0.6	0.19-0.68	0.2-0.6	0.23 - 0.51	0.23-0.68	(2-9%)	0.24 - 0.76
Eos#	Male	0.04-0.57	0.1-0.2	<0.01-0.5	0.0-0.1	0.03-0.37	0.05-0.64	0.08-0.92	0.0-0.64	0.04-0.81	0 - 0.43	0.03-0.85	(1-8%)	0.06 - 0.61
	Female	0.04-0.51	0.1-0.2	<0.01-0.4	0.0-0.82	0.03-0.37	0.04-0.49	0.04-0.75	0.0-0.54	0.04-0.06	0 - 0.28	0.03-0.86	(1-8%)	0.05-0.6

Continued.

Parameters	Country	France[6]	Canada[7]	Kuwait[8]	Mali[9]	Oman[10]	Kenya[11]	Thai[12]	Brazil[13]	Saudi Arabia[14]	Indonesia[4]	India[15] (Eastern)	India[16] (Southern)	Present western-India
	Age Range (yrs)	20-59	20-79	18-96	18-59	18-69	20-65	18-60	18-59	18-55	>17	18-40	20-70	18-94
Baso#	Male	0.0-0.09	0.0-0.1	0.01-0.1	0.0-0.11	0.002-0.05	0.01-0.08	0.0-0.1	0.0-0.62	0.02-0.16	0 - 0.05	0.01-0.08	(0-0%)	0-0.08
	Female	0.04-0.51	0.0-0.1	0.01-0.1	0.0-0.10	0.002-0.05	0.01-0.06	0.01-0.09	0.0-0.73	0.02-0.13	0 - 0.03	0-0.06	(0=0%)	0-0.07
RBC	Male	4.45-5.72	4.3-5.7	4.7-5.8	4.15-6.24	4.45-6.75	4.94-6.52	4.2-6.1	4.4-5.8	4.72-6.59	4.8 - 5.76	4.14-5.382	4.5-5.5	4.12-5.96
	Female	3.97-5.14	3.8-5.0	4.1-5.5	3.88-5.75	4.07-6.17	4.31-5.76	4.0-5.5	3.9-5.1	3.88-5.41	4.28 - 5.06	3.65-5.12	3.5-5.2	3.68-5.24
HGB	Male	13.4-16.7	13.6-16.9	13.8-16.4	12.4-17.5	12.4-16.4	14.5-18.7	12.7-16.9	13.0-16.9	13.4-18.0	13.76 - 15.84	12.4-16.9	12.3-17	11.6-16.6
	Female	11.5-14.9	11.9-14.8	11.3-13.9	12.0-14.9	11-15.1	12.0-16.5	12-14.9	11.5-14.8	10.1-14.8	11.5-14.1	10.3-14.3	9.9-14.3	10.3-14.4
HCT	Male	39-48	40-50	41-50	33-54	36-47	43-55	40-51	39-52	42-54	43-49.4	37.9-51.1	37-51	36.86-51.8
	Female	34-43	35-43	34-42	26-52	33-43	36-49	37-45	35-46	32-45	36.82 - 43.18	32.5-43.4	30-43	32.78-44.8
MCV	Male	79.5-93.6	82.5-98	80-93	72.1-96.4	62.5-88.5	76.5-95.5	80.6-98.8	81.5-100.2	71.2-96.0	82.72-92.48	78.7.3-99.7	78-97	77.9-98.94
	Female	76.1-94.0	82.5-98	77-92	39.2-118	62.5-88.5	73.4-95.8	80.4-95.9	81.0-100.1	69.7-95.4	81.2-92.8	73.4-96.8	72-96	76.05 - 96.22
RDW-CV	Male	-	11.4-13.5	12.5-15	11.9-17.4	11.1-17.8	11.3-14.7	11.9-14.5	12.0-15.2	12.1-15.9	12.4-14.2	12.5-15.3	-	12.3-15.9
	Female	-	11.4-13.5	12.4-16	11.6-24.3	11.1-17.8	11.4-15.8	11.7-15.0	11.9-15.4	12.2-17.9	12.5-14.7	12.3-16.44	-	12.3-17.02
PLT	Male	172-398	151-324	184-304	142-482	146-347	133-356	160-356	128-302	158-367	223-341	85.3-355	130-380	174-419.2
	Female	185-445	153-361	204-350	151-532	164-368	152-443	179-435	137-344	178-438	243.4-386.6	72.74-384.66	130-420	192.75-506

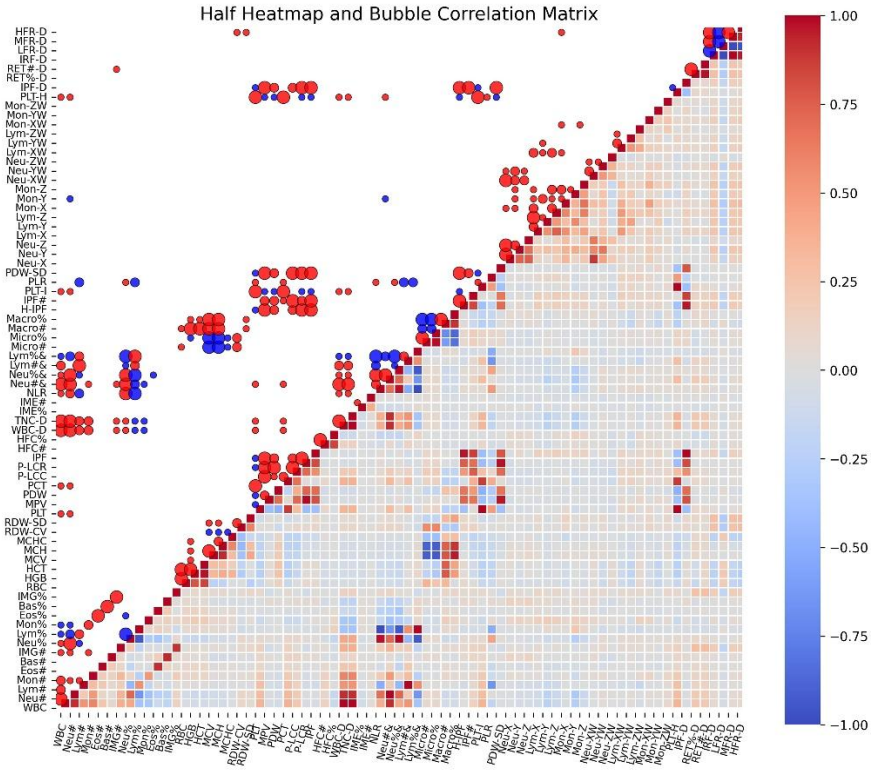

Figure 4: Correlation matrix.

Correlation analysis

The correlation matrix revealed expected and potentially informative inter-parameter relationships.

White blood cells: WBC correlated strongly with Neu#, Lym#, and Mon#. Absolute counts (#) correlated strongly with their respective percentages (%). NLR correlated positively with Neu% and Neu#. HFC (# and %) did not correlate with Lym# or Lym%. Notably, absolute counts (Neu#, Lym#, Mon#) did not correlate with their corresponding CPD parameters (mean intensities or distribution widths). However, within each cell type, CPD parameters were strongly intercorrelated (e.g., Neu-X, Neu-Y, Neu-Z).

Red blood cells: Strong positive correlations were observed within three groups: (1) HGB, RBC, HCT; (2) MCV, MCH; and (3) RDW-CV, RDW-SD. Micro (# and %) correlated positively with RDW-CV, while Macro (# and %) correlated strongly with MCV and MCH. IRF-D correlated strongly with MFR-D and HFR-D.

Platelets: PLT correlated strongly with PCT. MPV, PDW, P-LCC, P-LCR, and IPF showed good intercorrelations and also correlated positively with RUO parameters H-IPF, IPF#, and PDW-SD. Negative correlations: Lym% was negatively correlated with Neu%, NLR, and PLR. Micro (# and %) were negatively correlated with MCV and MCH. PLT was negatively correlated with MPV, PDW, P-LCR, IPF, and H-IPF (Figure 4).

DISCUSSION

Establishing population- and instrument-specific reference intervals (RIs) is fundamental to accurate clinical decision-making, particularly as modern hematology analysers introduce novel RUO parameters. Manufacturers often do not provide RIs for these newer parameters due to limited multi-ethnic healthy population data. Furthermore, even for established parameters, RIs should be verified or defined locally to account for demographic, genetic, environmental, and lifestyle factors, which are known to cause significant variation across ethnicities, geographic regions, age groups, and genders.[17-19]

However, implementing laboratory-specific RIs is challenging. The direct, gold-standard method for RI determination is expensive and time-consuming, making it difficult for many laboratories to adopt, particularly for hard-to-access populations such as paediatric and geriatric groups.[20] The current study addresses this gap by establishing comprehensive, age- and gender-specific RIs for 82 parameters (30 routine, 52 RUO) on the Mindray BC-780 analyser in a representative western Indian population, while also assessing precision and temporal stability.

Several parameters in this study consistently returned zero or near-zero baseline values, including NRBC#, NRBC%, InR#, InR‰, SRBC, LRBC, SMCV, and LMCV. This finding is biologically expected, as these parameters are highly specific indicators of pathological processes that are absent in healthy individuals. The absence of these parameters in healthy cohort not only validates the effectiveness of stringent screening criteria but also confirms that these novel markers are indeed specific to disease states, supporting their potential clinical utility when elevated.

Clinical relevance of RUO parameters

Before RUO parameters can be used diagnostically or prognostically, their reference intervals, precision, and stability must be established. Several RUO parameters have already shown clinical promise. High fluorescent cells (HFC# and HFC%) have been extensively studied in dengue.[21] The infected red blood cell count (InR#) has demonstrated high sensitivity and specificity for Plasmodium vivax malaria screening, though its utility is limited in P. falciparum malaria.[22] Sepsis is another area where RUO parameters, particularly white blood cell (WBC) cell population data (CPD) such as NeuX, NeuY, MonX, and MonY have shown potential for early diagnosis and monitoring.[23] Additionally, neutrophil and monocyte CPD parameters have proven useful in identifying suspected megaloblastic anaemia.[24] The current study provides the foundational reference data necessary for such clinical applications.

Precision and comparison with the literature

The precision analysis demonstrated good reproducibility for most parameters. Red cell parameters showed excellent precision (CV<1%), consistent with the high analytical stability of erythrocytes. Higher CVs observed for eosinophil, basophil, immature granulocyte, and certain platelet parameters (IPF, P-LCC) likely reflect their lower absolute counts, where minor absolute fluctuations translate into larger relative variability. These findings are comparable to those reported by Lin et al on the Mindray BC-7500 analyser. [25]

Temporal stability at room temperature

Temporal stability is critical for routine practice, particularly for samples transported to centralised laboratories or delayed due to high workload. Referred samples are often stored and transported at ambient temperatures rather than under refrigeration, and delayed testing can compromise sample integrity, leading to inaccurate results, repeat testing, delayed clinical decisions, and increased costs.[26,27]

The finding of the present study, that most routine (28/30) and RUO (44/52) parameters remain stable for 24 hours at room temperature, is reassuring. Parameters with limited stability- immature granulocytes (8 hours), macrocyte indices (8 hours), and reticulocyte-related parameters (4 hours)- should be prioritised for early analysis. These

results align with previous stability studies on different analysers. Oliveira et al reported similar patterns on the ABX Pentra 60, while Joshi et al noted that platelet and reticulocyte indices were less stable on the Sysmex XE-5000.[28,29] Imeri et al observed that stability varies by analyser, emphasising the need for instrument-specific assessments.[30] However, comparative data for RUO parameters remain limited.

A 10% deviation from baseline was selected as the threshold for clinically significant change in this study. This benchmark is widely used in stability analyses and is practical for evaluating a large panel of 82 parameters, including many novel RUO metrics for which parameter-specific total allowable error and biological variation targets have not yet been established by international consensus bodies.[31]

However, authors acknowledge that for certain well-characterised routine parameters with narrow TAE limits, such as haemoglobin and haematocrit, a 10% shift would represent a clinically significant change that would typically trigger clinical action. The application of a uniform 10% threshold across all parameters therefore, represents a conservative approach for RUO parameters while remaining clinically relevant for routine parameters.

Correlation analysis insights

The correlogram analysis provided insights into RUO parameters, particularly CPD parameters. Although neutrophil, lymphocyte, and monocyte CPD parameters reflect cell-specific characteristics, they did not correlate significantly with their corresponding absolute counts (Neu#, Lym#, Mon#) in healthy individuals. However, within each cell type, CPD parameters related to internal complexity (-X), nucleic acid content (-Y), and cell size (-Z) showed strong intercorrelations. It will be important to investigate whether these internal correlations deviate under disease conditions- for example, increased Neu-Y and Mon-X in sepsis or elevated Neu-X in megaloblastic anaemia.[23,24] Prospective studies are needed to validate these observations.

Age and gender trends in parameters

The divergent RBC/HGB trends by gender with age

The observed increase in hemoglobin and hematocrit with advancing age in females, contrasting with a decline in males, is clinically noteworthy. This pattern likely reflects the cessation of menstrual blood loss after menopause in females, coupled with age-related declines in androgen-stimulated erythropoiesis in males.

These findings highlight the importance of gender-specific RIs across different age strata. Similar divergent trends have been reported in other populations, further validating our findings.[32,33]

The increase in MCV and macrocyte percentage with age

The age-associated increase in mean corpuscular volume (MCV) and macrocyte percentage, observed in both genders, aligns with known physiological changes in erythropoiesis and nutritional status in older adults. This trend is consistent with previous reports from both Western and Asian populations, including a study on a Mindray BC-6800 analyser.[33,34]

Higher platelet counts in females with age-related decline

Higher platelet counts in females, particularly in younger age groups, followed by a decline with age, is a consistent finding in the literature. These differences, confirmed in large cohort studies, may be influenced by changes in the hormonal status, iron storage, or genetic factors.[35]

RUO parameters: CPD findings

The observed decrease in neutrophil cell population data (CPD) parameters (Neu-X, Neu-Y, Neu-Z) in older individuals and higher lymphocyte distribution widths in females are novel findings for the Mindray BC-780. Our results corroborate recent studies on other analysers, such as the Sysmex XN series, which have also established age- and sex-specific RIs for CPD parameters, suggesting these differences are biologically robust rather than instrument-specific.[36]

Comparison with other populations

The RIs established in this western Indian population showed notable differences from other Indian and global populations, likely reflecting genetic, environmental, dietary, and lifestyle influences.

Global comparison

When compared with global studies, the reference intervals (RIs) for WBC and neutrophil counts in the present study were comparable to those reported in the Kuwaiti cohort, but significantly higher than those observed in cohorts from Oman and Kenya.[8,10,11] Haemoglobin and red blood cell (RBC) counts did not show significant differences compared to global cohorts, although they were marginally lower in both genders. Platelet counts in the present study were higher than those reported in several populations, including those from Canada, Kuwait, Oman and Brazil.[7,8,10,13]

Within India

Comparison with studies from eastern and southern India highlights regional differences. For instance, WBC and neutrophil counts were higher, while eosinophil counts were lower in the present study. Red cell parameters showed no major regional variation. Notably, platelet counts were significantly lower in the eastern Indian population and slightly lower in the southern Indian

population compared to the present western Indian cohort.[15,16]

This study has several limitations. First, participants were recruited from a single reference laboratory in Surat, Gujarat, which may not fully represent the broader western Indian population, particularly rural communities. Second, while the sample size met CLSI C28-A3 minimum requirements for each subgroup (n>120), some subgroups (e.g., females aged >60 years, n=137) had smaller numbers, potentially affecting the precision of the 97.5th percentile estimates. Third, authors did not assess inter-individual biological variation, conduct a longitudinal stability assessment beyond 24 hours, or evaluate temporal stability under refrigerated conditions (4°C). Fourth, healthy status was defined based on routine health check-up parameters; therefore, subclinical conditions cannot be entirely excluded. Finally, instrument-specific reference intervals may not be transferable to other hematology analysers.

CONCLUSION

In conclusion, this study establishes comprehensive age- and gender-specific reference intervals for 82 hematological parameters (30 routine and 52 RUO) using the Mindray BC-780 analyser in a population from Gujarat, Western India. The findings highlight significant variability in key parameters across age and gender groups, emphasising the importance of localised reference intervals for accurate clinical decision-making.

Furthermore, the temporal stability analysis demonstrates that most parameters remain stable for up to 24 hours at room temperature, providing valuable insights for preanalytical quality control. These results address a critical gap in hematology diagnostics and pave the way for further research into the clinical utility of novel RUO parameters.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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Appendix 1: List, description and unit of routine and RUO parameters.

Parameters	Description of routine parameters	Unit
WBC	White blood cell count	$\times 10^3/\mu l$
Neu#	Neutrophil count	$\times 10^3/\mu l$
Lym#	Lymphocyte count	$\times 10^3/\mu l$
Mon#	Monocyte count	$\times 10^3/\mu l$
Eos#	Eosinophil count	$\times 10^3/\mu l$
Bas#	Basophil count	$\times 10^3/\mu l$
IMG#	Immature granulocyte count	$\times 10^3/\mu l$
Neu%	Neutrophil percentage	%
Lym%	Lymphocyte percentage	%
Mon%	Monocyte percentage	%
Eos%	Eosinophil percentage	%
Bas%	Basophil percentage	%
IMG%	Immature granulocyte percentage	%
RBC	Red blood cell count	$\times 10^6/\mu l$
HGB	Hemoglobin	gm/dl
HCT	Hematocrit	%
MCV	Mean corpuscular volume	fl
MCH	Mean corpuscular hemoglobin	pg
MCHC	Mean corpuscular hemoglobin concentration	gm/dl
RDW-CV	Red cell distribution width CV	%
RDW-SD	Red cell distribution width SD	fl
PLT	Platelet count	$\times 10^3/\mu l$
MPV	Mean platelet volume	fL
PDW	Platelet distribution width	—
PCT	Plateletcrit	%
P-LCC	Platelet large cell count	$\times 10^3/\mu l$
P-LCR	Platelet large cell ratio	%
IPF	Immature platelet fraction	%
NRBC#	Nucleated red blood cell count	$\times 10^3/\mu l$
NRBC%	Nucleated red blood cell percentage	/100 WBC
	Description of RUO parameters	
HFC#	High fluorescent cell count	$\times 10^3/\mu l$
HFC%	High fluorescent cell percentage	%
WBC-D	White blood cell count DIFF	$\times 10^3/\mu l$
TNC-D	Total nucleated cell count DIFF	$\times 10^3/\mu l$
IME%	Immature eosinophil percentage	%
IME#	Immature eosinophil count	$\times 10^3/\mu l$
NLR	Neutrophil-to-lymphocyte ratio	—
InR#	Infected red blood cell count	$\times 10^3/\mu l$
InR‰	Infected red blood cell permillage	‰
Neu#&	Neu# Minus IMG#	$\times 10^3/\mu l$
Neu%&	Neu% Minus IMG%	%
Lym#&	Lym# Minus HFC#	$\times 10^3/\mu l$
Lym%&	Lym% Minus HFC%	%
Micro#	Microcyte count	$\times 10^6/\mu l$
Micro%	Microcyte percentage	%
Macro#	Macrocyte count	$\times 10^6/\mu l$
Macro%	Macrocyte percentage	%
H-IPF	High fluorescent immature platelet fraction	%
IPF#	Immature platelet count	$\times 10^3/\mu l$
PLT-I	Platelet count impedance	$\times 10^3/\mu l$
PLR	Platelet-to-lymphocyte ratio	—
PDW-SD	Platelet distribution width SD	fl

Continued.

Parameters	Description of routine parameters	Unit
SRBC	Smaller distribution RBC count	$\times 10^6/\mu l$
LRBC	Larger distribution RBC count	$\times 10^6/\mu l$
SMCV	Smaller distribution mean corpuscular volume	fl
LMCV	Larger distribution mean corpuscular volume	fl
Neu-X	Mean neutrophil distribution side scatter intensity	—
Neu-Y	Mean neutrophil distribution side fluorescent light intensity	—
Neu-Z	Mean neutrophil distribution forward scatter intensity	—
Lym-X	Mean lymphocyte distribution side scatter intensity	—
Lym-Y	Mean lymphocyte distribution side fluorescent light intensity	—
Lym-Z	Mean lymphocyte distribution forward scatter intensity	—
Mon-X	Mean monocyte distribution side scatter intensity	—
Mon-Y	Mean monocyte distribution side fluorescent light intensity	—
Mon-Z	Mean monocyte distribution forward scatter intensity	—
Neu-XW	Neutrophil side scatter distribution width	—
Neu-YW	Neutrophil side fluorescent light distribution width	—
Neu-ZW	Neutrophil forward scatter distribution width	—
Lym-XW	Lymphocyte side scatter distribution width	—
Lym-YW	Lymphocyte side fluorescent light distribution width	—
Lym-ZW	Lymphocyte forward scatter distribution width	—
Mon-XW	Monocyte side scatter distribution width	—
Mon-YW	Monocyte side fluorescent light distribution width	—
Mon-ZW	Monocyte forward scatter distribution width	—
PLT-H	Platelet count hybrid	$\times 10^3/\mu l$
IPF-D	Immature platelet fraction DIFF	%
RET%-D	Reticulocyte percentage DIFF	%
RET#-D	Reticulocyte count DIFF	$\times 10^6/\mu l$
IRF-D	Immature reticulocyte fraction DIFF	%
LFR-D	Low fluorescent ratio DIFF	%
MFR-D	Middle fluorescent ratio DIFF	%
HFR-D	High fluorescent ratio DIFF	%