

Lab Values

PART 4: INTERPRETATION OF CLINICAL LABORATORY DATA

Laboratory Value Sources

- Reliable sources:
 - MSD Online
 - RCPA Manual
 - LabTests Online

Pharmacy Student Survival Guide, 3E (Nemire, Pharmacy Student Survival Guide) 3rd Edition. [Ruth E. Nemire](#) (Author), [Karen L. Kier](#) (Author), [Michelle T. Assa-Eley](#) (Author)
Blood Chemistry and CBC analysis. 2002 Weatherby
Douglas Hanly Moir Reference Range

TEST	FULL NAME	LOW VALUE	HIGH VALUE
RBC	Red blood cell count	<p>Known as anemia</p> <p>Acute or chronic bleeding</p> <p>RBC destruction (e.g., hemolytic anemia, etc.)</p> <p>Nutritional deficiency (e.g., iron deficiency, vitamin B12 or folate deficiency)</p> <p>Bone marrow disorders or damage</p> <p>Chronic inflammatory disease</p>	<p>Known as polycythemia</p> <p>Dehydration</p> <p>Lung (pulmonary) disease</p> <p>Kidney or other tumor that produces excess erythropoietin</p> <p>Smoking</p> <p>Genetic causes (altered oxygen sensing, abnormality in hemoglobin oxygen release)</p>

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Complete Blood Count (CBC)

The CBC includes:

- haemoglobin (Hb)
- haematocrit (Hct)
- white blood cell indices
- red blood cell indices
- platelets

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Complete Blood Count (CBC)

- ❑ Aids diagnosis and assessment of **anaemia**, nutritional deficiencies, blood disorders, infection, and many other disorders.
- ❑ provides important information about the types, populations, and health of blood cells
- ❑ Red Cell Distribution Width (RDW) is commonly but not always included in the FBC as part of the red cell indices, depending on the pathology service provider.

RDW is relevant to the evaluation of vitamin deficiencies, including vitamin B12.

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Hemoglobin (Hb)

Hb is the oxygen-carrying compound found in RBC. Hb level is a direct indicator of the oxygen-carrying capacity of the blood. Adaptation to high altitudes, extreme exercise, and pulmonary conditions may cause variations in Hb values.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male	14-18 g/dL	SI 8.7-11.2 mmol/L	14-15 g/dL	<10 or >17g/dL
Female	12-16 g/dL	SI 7.4-9.9 mmol/L	13.5-14.5 g/dL	<10 or >17g/dL

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Hemoglobin (Hb)

INCREASED HAEMOGLOBIN

- Polycythemia vera
- COPD
- Chronic smokers
- Athletes
- People living at high altitudes.

DECREASED HAEMOGLOBIN

- Anaemia of all types, particularly iron deficiency anaemia (IDA)
- Blood loss
- Haemolysis
- Pregnancy
- Increased fluid intake or fluid replacement

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Haematocrit (Hct)

The Hct describes the volume of blood that is occupied by RBC. It is expressed as a percentage of total blood volume. Another name for Hct is packed cell volume (PCV). As a rule of thumb, the Hct value is generally about three times the value of Hb.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male	SI 0.39-0.49	39-49%	0.40-0.48 SI	<0.32 or >0.55
Female	SI 0.33-0.43	33-43%	0.37-0.44 SI	<0.32 or >0.55

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Haematocrit (Hct)

INCREASED HAEMATOCRIT

- Dehydration (burns, vomiting/diarrhoea)
- Polycythemia vera
- COPD
- People living at high altitudes.

DECREASED HAEMATOCRIT

- All types of anaemias
- Blood loss
- Haemolysis
- Pregnancy
- Cirrhosis
- Hyperthyroidism
- Leukaemia.

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Red Cell Count (RCC)/Erythrocyte Count

- RBC are produced in the bone marrow.
- They are released into the systemic circulation and serve to transport oxygen from the lungs to the body tissues.
- After circulating for a life span of approximately 120 days, the RBC are cleared by the reticuloendothelial system.
- The actual amount of RBC per unit of blood is the RCC.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male	SI 3-5.9x10 ¹² /L	4.3-5.9x10 ⁶ cells/mm ³	4.2-4.9x10 ¹² /L	<3.8 or >6.0
Female	SI 3.5-5.0x10 ¹² /L	3.5-5.0x10 ⁶ cells/mm ³	4.0-4.5x10 ¹² /L	<3.5 or >5.0

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Red Cell Count (RCC)/Erythrocyte Count

INCREASED RCC (*erythrocytosis*)

- > Polycythemia vera
- > High altitudes
- > Strenuous exercise

DECREASED RCC (*erythropenia*)

- > Various types of anaemias
- > Lymphomas and leukaemia
- > Menstruating females typically have decreased RCC and Hb due to blood loss.

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Mean Cell Volume (MCV)

Or mean corpuscular volume, the MCV provides an estimate of the average volume of the erythrocyte.

- The higher the MCV, the larger the average size of the RBC
macrocytic/macrocytosis
Conversely, cells with a low MCV are referred to as *microcytic*.
- *Normocytic* RBCs have an MCV that falls within the normal range.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Males & Females	SI 80-98fL	76-100um ³	82.0-89.9fL	<78.0 or >95.5fL

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Mean Cell Volume (MCV)

INCREASED MCV

Folate deficiency
 B12 deficiency
 Alcoholism
 Chronic liver disease
 Hypothyroidism
 Anorexia
 Particular medications.

DECREASED MCV

Iron deficiency
 anaemia
 Haemolytic anaemia
 Lead poisoning
 Thalassemia.

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MCH

Also known as Mean Corpuscular Haemoglobin, the MCH indicates the average weight of Hb in the RBC.

Cells with a low MCH are pale in color and are referred to as *hypochromic*.

Cells with an increased MCH are *hyperchromic* Cells with normal amounts of Hb are *normochromic*.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Males & Females	27-33pg	n/a	28.0-31.9pg	<24.0 or >34.0pg

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MCH

INCREASED MCH

- Folate or Vitamin B12 deficiency.
- In individuals with hyperlipidaemia MCH may be falsely elevated because of specimen turbidity.

DECREASED MCH

- Iron deficiency anaemia.

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MCHC

Also known as mean corpuscular haemoglobin concentration, MCHC is a measure of average Hb concentration in the RBC.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	0.32-0.36 SI	32.0-36.0g/dL	32.0-35.0g/dL	n/a

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MCHC

INCREASED MCHC

- Hereditary spherocytosis.

DECREASED MCHC

- Iron deficiency anaemia
- Haemolytic anaemia
- Lead poisoning
- Thalassemia.

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Reticulocytes

- Reticulocytes are immature RBC formed in the bone marrow.
- An increase in reticulocyte count usually indicates increased RBC production, but may also be indicative of a decrease in the circulating number of mature erythrocytes.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & female	0.1-2.4%	SI 0.001-0.02	0.5-1% OR 0.005-0.01	>2% OR 0.02

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Reticulocytes

INCREASED RETICULOCYTES

- Haemolytic anaemia
- Haemorrhage
- Sickle cell disease.
- Increased reticulocytes are also indicative of response to treatment of anaemias secondary to iron, B12, or folate deficiency.

DECREASED RETICULOCYTES

- Infectious causes
- Alcoholism
- Renal disease (from decreased erythropoietin)
- Toxins
- Untreated iron deficiency anaemia
- Drug-induced bone marrow suppression.

** Reticulocyte Count is typically not a standard part of the FBC, and is often ordered separately.

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White Cell Count (WCC)

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	3.2-11.3 x10 ⁹ /L SI	3.2-11.3 x10 ³ /mm ³	5.0-7.5 x10 ⁹ /L	<3.0 or >13.0 x10 ⁹ /L

- Also known as leukocyte count, the WCC represents the total number of WBC in a given volume of blood.
- Mature WBC exist in many forms, including neutrophils, lymphocytes, monocytes, eosinophils, and basophils. White cell indices provides differential provides a breakdown of the percentage of each type of WBC.

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White Cell Count (WCC)

INCREASED WCC (*leukocytosis*)

- Infection
- Leukaemia
- Trauma
- Thyroid storm
- Corticosteroid use.
- Emotion, stress, and seizures may also increase WCC.
- WCC >50,000 cells/mm³ may cause false elevations in Hb and MCH.

DECREASED WCC (*leukopenia*)

- Viral infection
- Aplastic anaemia
- Bone marrow depression caused by the use of chemotherapy or anticonvulsants.

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Neutrophils

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	1.8-8.0x10 ⁹ /L	35-74%	4-6x10 ⁹ /L	<3 or > 8 x10 ⁹ /L

Neutrophils are the most common type of WBC. Their primary function is to fight bacterial and fungal infections by phagocytosis of foreign particles. Neutrophils may also be involved in the pathogenesis of some inflammatory disorders, for example, rheumatoid arthritis and inflammatory bowel disease. Bands are immature neutrophils. An increase in bands, often referred to as a “shift to the left” or “left shift,” may occur during infection or leukaemia.

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Neutrophils

INCREASED NEUTROPHILS (*neutrophilia*)

- Infection
- Metabolic disorders (eg, diabetic ketoacidosis, DKA)
- Uremia
- Response to stress, emotional disturbances,
- Burns
- Acute inflammation
- Use of medications such as corticosteroids.

DECREASED NEUTROPHILS (*neutropenia*)

- Viral infections (eg, mononucleosis, hepatitis)
- Septicemia
- Overwhelming infection
- Use of chemotherapy agents

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Lymphocytes

- Lymphocytes are the second most common type of circulating WBC. They are important in the immune response to foreign antigens.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	1.2-5.2x10 ⁹ /L	12-52%	2.4-4.4x10 ⁹ /L	<2 or > 5.5 x10 ⁹ /L

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Lymphocytes

INCREASED LYMPHOCYTES

(*lymphocytosis*)

- Hepatitis
- Viral infections (EBV, chickenpox, herpes simplex, herpes zoster etc.)
- Some bacterial infections (eg, syphilis, brucellosis)
- Leukaemia and multiple myeloma

DECREASED LYMPHOCYTES

(*lymphopenia*)

- Acute infections
- Burns & trauma
- SLE
- HIV
- Lymphoma

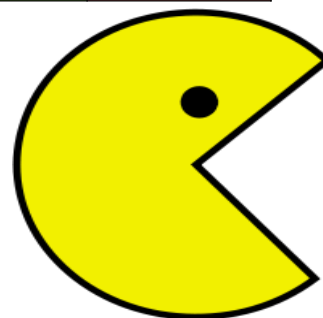
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Monocytes

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	0.0-1.0x10 ⁹ /L	0-10%	<0.7x10 ⁹ /L	>1.5x10 ⁹ /L

- Monocytes are synthesized in the bone marrow, released into the circulation, and subsequently migrate into lymph nodes, spleen, liver, lung, and bone marrow. In these tissues, monocytes mature into macrophages and serve as scavengers for foreign substances.



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Monocytes

INCREASED MONOCYTES

(*monocytosis*)

- Recovery phase of some infections
- Subacute bacterial endocarditis (SBE)
- Tuberculosis (TB), syphilis and malaria
- Leukemia and lymphoma.

□ .

DECREASED MONOCYTES

(*monocytopenia*)

- Not usually associated with a specific disease but may be seen with use of bone marrow suppressive agents or severe stress

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Eosinophils

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male	SI 0.0-0.8x 10 ¹² /L	0-8%	<0.3x10 ¹² /L	n/a

Eosinophils are phagocytic WBC that assist in the killing of bacteria and yeast.

They reside predominantly in the intestinal mucosa and lungs.

They are also involved in allergic reactions and in the immune response to parasites.

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Eosinophils

INCREASED EOSINOPHILS (*eosinophilia*)

- > Allergic disorders
- > Allergic drug reactions
- > Collagen vascular disease
- > Parasitic infections
- > Immunodeficiency disorders
- > Some malignancies.

DECREASED EOSINOPHILS (*eosinopenia*.)

- > Increased adrenal steroid production.

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Basophils

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Females	SI 0.0-0.3 x10 ¹² /L	<0.3%	0.0-0.1 x10 ¹² /L	>0.5 x10 ¹² /L

Basophils are phagocytic WBCs present in small numbers in the circulating blood.

They contain heparin, histamine, and leukotrienes and are probably associated with hypersensitivity reactions.

INCREASED BASOPHILS

(*basophilia*)

Hypersensitivity reactions to food or medications

Certain leukaemias

Polycythemia vera.

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Platelets

Platelets are a critical element in blood clot formation.

INCREASED PLATELETS (*thrombocytosis, thrombocythemia*)

- Infection
- Malignancies
- Splenectomy
- Chronic inflammatory disorders (eg, rheumatoid arthritis)
- Polycythemia vera
- Haemorrhage
- Iron deficiency anemia
- Myeloid metaplasia.

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	Conventional ref range	Conventional I ref range	Optimal ref range	Alarm range
Male & Female	150-450 x10 ⁹ /L	150-450 X10 ⁹ /mm ³	155-385 x10 ⁹ /L	<50 or >700 X10 ⁹ /L

DECREASED PLATELETS (*thrombocytopenia*)

- Autoimmune disorders such as idiopathic thrombocytopenic purpura (ITP)
- Aplastic anaemia
- Radiation
- Chemotherapy
- Space-occupying lesion in the bone marrow
- Bacterial or viral infections
- Use of heparin or valproic acid.

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Serum Iron

The serum iron measures the concentration of iron bound to the iron transport protein transferrin.

Under normal circumstances, approximately one-third of transferrin molecules are bound to iron.

INCREASED SERUM IRON

Excessive iron therapy
 Frequent transfusions
 Pernicious anaemia
 Hemolytic anaemia
 Thalassemia
 Haemochromatosis (iron overload).²

In iron deficiency anaemia, serum iron levels may remain within the lower limit of normal. Thus, serum iron levels are best interpreted along with total iron-binding capacity (TIBC).

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	Conventional I ref range	Conventional I ref range	Optimal ref range	Alarm range
Male	SI 14–32 µmol/L	80–180 µg/dL	8.96-17.91 µmol/L	<4.5 or >35.82 µmol/L
Female	SI 11–29 µmol/L	60–160 µg/dL	8.96-17.91 µmol/L	<4.5 or >35.82 µmol/L

DECREASED SERUM IRON

Iron deficiency anaemia, (microcytic, hypochromic anaemia).
 Poor dietary intake
 Pregnancy
 Blood loss associated with menses
 Peptic ulcer disease, and gastrointestinal bleeding
 Malignancies
 Anaemia of chronic disease
 Chronic renal disease
 Haemodialysis.

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Ferritin

Ferritin is the storage form of iron. The serum ferritin level provides an accurate reflection of total body iron stores.

INCREASED SERUM FERRITIN

Haemochromatosis

Recent iron supplementation or transfusion

Since ferritin is an acute phase reactant it may also be elevated in patients with malignancies, inflammatory disorders, or infection/fever.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male	15-250ug/L	n/a	n/a	<8ug/L >500ug/L
Female	10-150ug/L After menopause 10-263ug/L	n/a	n/a	n/a

DECREASED SERUM FERRITIN

Iron deficiency anaemia

Severe protein deficiency

Hemodialysis

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TIBC

TIBC is an indirect measurement of the iron transport protein transferrin.

The test is performed by adding an excess of iron to a plasma sample.

Any excess unbound iron is removed from the sample, and the serum iron concentration in the sample is determined.

The measured serum iron concentration reflects the TIBC of serum transferrin.

INCREASED TIBC

- Iron deficiency anaemia
- Pregnancy
- Oral contraceptive use.

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	SI 45-82 μmol/L	250-350 μg/dL	44.8-62.7 μmol/L	n/a

DECREASED TIBC

- Anaemia of chronic disease
- Malignancy
- Infections
- Uremia
- Cirrhosis
- Hyperthyroidism
- Haemochromatosis.

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Serum B12

Measures serum levels of vitamin B12.
Vitamin B12 is important in DNA synthesis, neurologic function, and haematopoiesis.
Deficiency of vitamin B12 produces a macrocytic anaemia.

SIGNS & SYMPTOMS

- Glossitis
- Parasthesias
- Muscle weakness
- Gastrointestinal symptoms
- Loss of coordination
- Tremors
- Irritability

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	SI 148–664 pmol/L	n/a	n/a	MUST BE IX

DECREASED SERUM B12 CAUSES

- Inadequate dietary intake (rare except for vegan diets)
- Deficiency of intrinsic factor (necessary for absorption of B₁₂)
- Increased requirements.
- Pernicious anaemia
- Gastrectomy
- Crohn's disease
- Small bowel resection
- Intestinal infections
- Medication use including colchicine or neomycin.

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Homocysteine 4-14 umol/L

Increased levels:

Cardiovascular Disease
Cerebrovascular Disease
Peripheral vascular disease
Cystinuria
Folate B6 or B12 deficiency
Folate deficiency

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Serum B12

Increased levels of vitamin B12 in the blood can exist for a number of reasons, which can be divided roughly into the following categories.

The test was simply carried out too soon after the taking of vitamin B12 supplements

The body is failing to use the B12 correctly

A severe disease is present

Cancer BioMarker

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	SI 148–664 pmol/L	n/a	n/a	MUST BE IX

Alongside alcoholism

Genetic make-up

An impaired B12 absorption and increased transport molecules in the blood

Diseases of the liver, kidneys and the blood, such as leukemia, can be considered potential reasons for an increased vitamin B12 blood level

1E. Andr s, K. Serraj, J. Zhu, A.J.M. Vermorken. The pathophysiology of elevated vitamin B12 in clinical practice QJM Feb 2013

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Serum Folate

Measures serum folate. Like vitamin B12, folate is a vitamin necessary for synthesis of DNA.

- Deficiency of folate results in megaloblastic anaemia.

DECREASED SERUM FOLATE CAUSES

- Inadequate intake (major cause)
- decreased absorption 'TRAPPING'
- Inability to convert folic acid to the active form tetrahydrofolate

	Conventional ref range	Conventional ref range	Optimal ref range	Alarm range
Male & Female	SI 6.8–56.8 nmol/L	n/a	n/a	n/a

DECREASED SERUM FOLATE

- Alcoholism
- Poor nutrition
- Pregnancy
- Hyperthyroidism
- Crohn's disease
- Small bowel resection
- Coeliac disease
- Medication use including trimethoprim, triamterene, methotrexate, phenytoin, and sulfasalazine.

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