Sudan University of Science and Technology

College of Graduate Studies

Normal Reference Values of Blood Cell Countand Indices among Different Ages and Sexes of United Arab Emirates Population

القيم المرجعية الطبيعية لتعداد خلايا الدم ومؤشراتها بين مختلف الأعمار والجنس لمواطني دولة الأمارات العربية المتحدة

A Dissertation Submitted in Partial Fulfillment for Master Degree in Hematology and Immunohematology

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بسم الله الرحمن الرحيم

"وأنزل اللهُ عليك الكتاب والحكمة وعلمك ما لم تكن تعلم"

صدق الله العظيم

(سورة النساء 113)

Dedication

To

The candles which burn to light our life and themercifulsouls which I pray for them to prolong their ages……my parents

To

Myhappiness source… brothers, wife, son and daughter

To

My respectful supervisorProf.Babiker Ahmad Mohammad,who helped me to achieving this studyand to all our respectful doctors and teachers in SUST- lab department.

To

Myfriends, who gave me a favor and supportedme,

To

Anyonewhoever stretch his hand for help

To

All these I dedicated my study.

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Great thanks for **my God Allah** for his immortal grace, and for his endless blessing.

Also deeply thanks tomy supervisor**Dr. BabikerAhmed Mohammad**for his helps insupervisionand to all our respectful **doctors and teachers** in SUST- **hematology department** for their great efforts during study period.

A lot of thanks to **all staff**in hospitals and clinics where Icollect samples for their assistance and thanks sends to all study **participants**.

Finally, thanks to everyone who help us in this research.

Abstract

This study was conducted in United Arab Emirates (UAE) to establish native reference hematological ranges which include Red blood cells count and indices, White blood cells count and Platelets count) in the UAE population.

The study was carried out on 365 apparently healthy participants, with ages ranging from 5 to 68 years; the subjects were divided into four groups depending on the age. A questionnaire was fulfilled by each subject and EDTA anti coagulant venous blood samples were collected from each subject and Hematological parameters (WBCs, RBCs, PCV, MCV, MCH, MCHC and Platelets) were estimated by using automated hematological analyzer (Sysmex) and a blood film was done for each.The mean and standard deviation of each parameter was calculated for each age group. The final results showed that WBCs count remained more or less similar among the different age groups and the difference between males and females was not significant ($p>0.05$). The RBCs count shows a slight fluctuation with agein both sex except the significant increase in 13-18 and >18 years old males. The hemoglobin and hematocrit levels showed a slight but not significant increase with age in males except in the age groups13-18 and over 18 years old. On the other hand,females' hemoglobin and hematocrit levels showed slight changes with age, in addition to significant lower than that of males in age groups of (13-18) and (> 18) years old. The MCV results show slight changes between age groups, except the significant increase in >18 years old males and females. The MCH and MCHC levels show insignificantly increase with age to reach the peak in >18 years old males and females. Platelets count shows a constant insignificant decrease in count with

age. In addition to that female platelets count in age group (13-18) and >18 shows slightly higher than that in males in the same age groups.

Literature reviews from different countries were reviewed. Also the causes of reduced in Hb and MCV results were reviewed.Finally the study results showedan expected pattern in all analytes except the Hb and MCV results for UAE population. They were significantly the lowest in all age groups of our study population which may be due to the high prevalence of hereditary and acquired anemia in the UAE.

Key words: reference hematological ranges, Hemoglobin, Red cells, White cells, Platelets, Red cell indices.

الخلاصة

أجريت هذه الدراسة التحليلية في دولة الإمارات العربية المتحدة لتحديد القيم والمؤشرات الدموية المختلفة في المجتمع الإماراتي والتي تشمل فحص الدم الشامل-تعداد خلايا الدم الحمراء ومؤشراتها ،وخلايا الدم البيضاء والصفائح الدموية. وقدأجريت هذه الدراسة على (**365**) مشاركا سليما بأعمارتتراوح ما بين (**5- 68**) عاما، تم تقسيمهم حسب العمرإلى أربع مجموعات.طلب من المشاركين تعبئة الاستبيان الخاص بالدراسة ثم سحبت عينات بأنابيب مخبريه تحتوي مانع للتخثر وجمعها لفحص تعداد خلايا الدم ومؤشراتها (كريات الدم الحمراء والبيضاء والصفائح الدموية بالإضافة إلى معدل خضاب الدم ,حجم الخلايا المكدسة معدل حجم الخلية الحمراء ومعدل هيموجلوبين الخلية) وذلك باستخدام جهاز تحليل الدم الآلي (سيسمكس) بالإضافة إلى عمل شريحة دموية (لطخه).كما تم حساب المتوسط الحسابي والانحراف المعياري لكل فئة عمرية.

أظهرت النتائج أن عدد كريات الدم البيضاء تقريبا متماثلة بين مختلف الفئات العمرية وأن الفرق بين الذكوروالإناث لم يكن كبيرا ($P> 0.05$). تعداد كريات الدم الحمراء متقارب بين الفئات العمرية لكلا الجنسين باستثناء زيادة ملحوظة في الفئات العمرية **13-18 و> 18** عاما من الذكور.كما أظهرت مستويات خضاب الدم وحجم الخلايا المكدسة زيادة طفيفة مع التقدم بالسن عند الذكوروزيادة ملحوظة بالفئات العمرية(**13-18) و (<18**)عاما.أما عند الإناث فكانت التغييرات طفيفة مع التقدم بالسن،كما أن مستويات خضاب الدم وحجم الخلايا المكدسة أقل عن الذكور بشكل واضح في الفئات العمرية من (**13-18**) و (> **18**) عاما.

نتائج معدل حجم الخلايا تظهرتغيرات طفيفة بين مختلف الفئات العمرية،و زيادة ملحوظة في الفئة العمرية(> **18**)عاما لكلا الجنسين. كما أن معدل تركيز خضاب الدم يظهرزيادة معنوية مع التقدم بالسن للوصول إلى الذروة في الفئة العمرية(> **18**)عاما للذكور والإناث.

يظهر تعداد الصفائح الدموية انخفاضا ضئيلا وثابتا مع التقدم بالسن. بالإضافة إلى أن الصفائح الدموية عند الإناث أعلى قليلا منها عند الذكورفي الفئة العمرية (**13-18**) و(> **18**)عاما.

تم استعراض وتضمين العديد من المطبوعات, الكتب, المجلات العلمية والدراسات التي لها علاقة بالموضوع من مختلف البلدان. كما تم استعراض أسباب الانخفاض في نتائج مستوى خضاب الدم ومعدل حجم خلايا الدم الحمراء.

أخيرا تظهر نتائج الدراسة النمط المتوقع في الفحص الشامل لتعداد خلايا الدم ومؤشراته باستثناء نتائج مستوى خضاب الدم (الهيموجلوبين) ومعدل حجم خلايا الدم الحمراء بالمجتمع الإماراتي, حيث كانت الأقل في جميع الفئات العمرية في مجتمع الدراسة لدينا والتي قد تكون نتيجة لارتفاع معدل انتشار فقرالدم الوراثي والمكتسب في دولة الإمارات العربية المتحدة.

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Abbreviations

a.	WBCs	White Blood Cells
b.	RBCs	Red Blood Cells
c.	PLTs	Platelets
d.	Hb	Hemoglobin
e.	Hct	Hematocrit
f.	MCV	Mean corpuscular volume
g.	MCH	Mean corpuscular hemoglobin
h.	MCHC	Mean corpuscular hemoglobin concentration
i.	CBC	Complete Blood Count
j.	EDTA	Ethylene Diamine Tetra Acetic acid
k.	UAE	United of Arab Emirates
l.	KSA	Kingdom of Saudi Arabia
m.	SPSS	Statistical Package for the Social Sciences.

Introduction and Literature review

1-1- General introduction:

Establishing the reference range of any analyte is an extreme importance for making a medical decision.Most studies conducted around the world to establish reference hematological ranges showed significant differences among different races and populations. There are manyfactors may affect the reference range of the hematological parameters like: age, sex, ethnic background, body build, genetics, nutritional and environmental factors. Specially altitude. (El-Hazmi, 2004), (Lewis, 2011).

This study is conducted in Abu Dhabi, and its surrounding cities, the capital of the United Arab Emirates (UAE) which is part of the Arabian Peninsula. It occupies about 83,600 square kilometers, andthe population is around (9.2millions) in 2013, where the national citizen is estimated to be (1.4 millions) from them.The climate of UAE is hot and humid in summer and moderate in winter. (United Arab Emirates,free encyclopedia)

Our study importance comes from the fact that the purpose of the laboratory tests is to identify abnormal results.However, results would not be considered abnormal until it is compared to a normal reference.

The normal reference should be determined carefully by selecting a sample of normal healthy individuals who are representative for the population, analyze their specimens and averaging out their test results. (Lewis, 2011),(Shahbaba, 2011).

Literature shows that the influence of race and sex on the hematological ranges is very significant, which make it very critical and important for every population to establish their own reference ranges.

Currently most reference hematological ranges are imported from western references which may or may not fit our population. Hence the urgent need for a native study in the UAE prompts me to do this project.

1.2- Literature review

1.2.1- Blood constituent and function

Blood is a connective tissue, composed of cellsand other contents, suspended in transparent fluid called *plasma*, circulate through the body; provides communication between the cells of different parts of the body and the externalenvironment.It carries:

• Oxygen from the lungs to the tissues and carbondioxide from the tissues to the lungs for excretion

• Nutrients from the alimentary tract to the tissues andcell wastes to the excretory organs, principally thekidneys.

• Hormones secreted by endocrine glands to their targetglands and tissues

• Protective substances, e.g. antibodies, to areas ofinfection

• Clotting factors that coagulate blood, minimizing itsloss from ruptured blood vessels.(Welson, 2001)

Plasma constitutes about 55% and cells about 45% of blood volume.

The study of cellular components of blood: erythrocytes, leukocytes, and platelets areusually performed as a hematological screening test to determine whether there are quantitative abnormalities in these cells.(Mckenzie)

This screening test known as the Complete Blood Count (CBC) which consists of Red Blood Cells (RBCs) count, White Blood Cells (WBCs) count, platelets count, and measurement of hemoglobin (Hb) and other RBCs indices like; mean red cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC) and a few more. (Medline plus, 2013).

Changes in the concentration of these cells occur from infancy until adulthood.

At birth, the total hemoglobin (Hb) level, red blood cell (RBC) count and packed cell volume (PCV) are shown to be higher than at any other period of life.

The levels of these parameters then decrease during the next few months after birth. The hemoglobin content and the red cells then gradually rise to adult levels by the age of puberty.

In general, the female levels are lower than the male levels.(El-Hazmi, 2004)

When we go for a complete physical blood test, you will probably undergo a series of tests to evaluate the composition and concentration of all the cellular components of blood.(Buzzle, 2013)**, (**El-Hazmi, 2004).

The Complete Blood Count helps evaluate the blood and the bone marrow, and also performed to ensure oxygen carrying capacity of the blood, identify infections, diagnose anemia and leukemia and also gauge the effect of chemotherapy and radiation therapy on blood production cells.(Medline plus, 2013).

1.2.2- Definitions of various hematological Parameters

1.2.2.1- White blood cells (WBCs)

White Blood Cells or Leukocytes are an important part of the body's defense system which broadly grouped into agranulocytes and granulocytes cells, based on the absence or presence of specific staining granules.

Agranulocytes include lymphocytes and monocytes, while granulocytes include neutrophils (polymorphs), eosinophils and basophils.Lymphocytes are further divided

into B cells, T cells and natural killer (NK) cells. Monocytes give rise to macrophages, whose main function is to ingest and destroy foreign particles and organisms.**(**Appendix A), (Hoffbrand, 2001), (Medline plus, 2013). (Miller, 2004)

1.2.2.1.1- Normal TWBCs count: (4.0-11.0) $\times 10^9$/L.(Hoffbrand, 2001)

1.2.2.1.2-Thedifferential count percentages of leukocyte are: (Hoffbrand, 2001)

- Neutrophils: 50 – 75%
- Lymphocytes: 15 – 35%
- Basophils: 1%
- Eosinophils: 1 – 4%
- Monocytes: 2 – 8%

1.2.2.1.3- *HighWBCs count*indicates infection, inflammation, allergy,certain drugs or medications,systemic illness, leukemiaand tissue injury caused due to burns.

1.2.2.1.4- *Low WBCs count* due to nutritional deficiency,certain infections,Medication, autoimmune disorders, cancers and chemotherapy medicines.

A low white blood cell counts renders an individual highly susceptible to infections and illnesses.(Medline plus, 2013),(Mayo Clinic.2013 Jan 03)

1.2.2.2-Red Blood Cells (Erythrocyte):

Bloodcells which are;Circular, nonnucleated,highly flexible, biconcave disc,8 μmdiameter, 2.1μm thickness,Floating in the plasma with WBCs, Platelets and other elements to form blood.(Hoffbrand, 2001), (Lynch, 1976).

1.2.2.2.1- The main function of red cell is to carry oxygen to the tissues and return carbon dioxide from tissues to the lungs. In order to achieve this gases exchange they contain the specialized contenthemoglobin (Hb).(Hoffbrand, 2001).

RBCsLife span is 120 days and they have ability to generate energy as ATP for maintenance of their volume, shape and flexibility.

Measurements of red cell numbers, volume and hemoglobin content are routine and useful assessments made in clinical practice.(Welson, 2001).

1.2.2.2.2- Definitions and Calculation of Erythrocyte Parameters:

1.2.2.2.2.1- Red Blood cell(RBC) count isthe number of red blood cells in a volume of blood(per liter (L) or per cubic millimeter (mm3) of blood.(Medline plus, 2013). (Theml, 2004)

1.2.2.2.2.2- Hemoglobin. This is the weight of hemoglobin inwhole blood, measured in grams per dl.(Welson, 2001).

1.2.2.2.2.3- Packed cell volume (PCV) or **Hematocrit (HCT):** is the percentage of relative mass ofRBCs to the whole blood, used as a simple screening test for anemia(orvolumeof red cells in 1 liter or 1 mm^3 of whole blood).

1.2.2.2.2.4- MCV:is theaverage volume of one red cell expressed in femtoliter(fl).
MCV is increased in macrocytic anemias and decreased in iron deficiency, thalasemia and secondary anemia.(Medline plus, 2013). (Theml, 2004).

MCV= (PCV%/RBCs in million per µl) ×10 fl**.** (Lynch, 1976),(Welson, 2001).

1.2.2.2.2.5- MCH: is the average amountof hemoglobin in each red cell, measured in (pg). It is directly proportional to the amount of hemoglobin and also to the size of the red cell.

MCH = (Hb$_{g/dl}$/RBCs in million per µl) ×10 pg.(Lynch, 1976),(Welson, 2001).

1.2.2.2.2.6- MCHC: Mean cell hemoglobin concentration (MCHC) refers to the average concentration of hemoglobin in a given volume of packed RBCs, Reporting unit is g/dl. (Or the amount of hemoglobin in 100 ml of red cells).

MCHC= (Hb$_{g/dl}$ / PCV) ×10. (Lynch, 1976),(Welson, 2001).

1.2.2.3- Platelets (Thrombocytes):

Plateletsarevery small non-nucleated blood cell, 2 to 4 um in diameter, derived from the cytoplasm of megakaryocytes in red bone marrow, each megacaryocyte is responsible for the production of 4000 platelets, and then enter the blood circulation.(Hoffbrand, 2001), (Welson, 2001).

1.2.2.3.1-Function of platelets:Plateletsplay essential functions (along with the coagulation factors) in blood clottingprocess (***homeostasis*)** to prevent excessive loss of blood. (Hoffbrand, 2001).

The live span ofPlatelet about 7- 10 days; the body continually renews platelets supply by producing new platelets in the bone marrow.(Hoffbrand, 2001), (Welson, 2001).

1.2.2.3.2- Normal rangeof platelets count is (150-400) ×10^9/L.(Burnett, 2005).

1.2.2.3.3-Low platelet count is thrombocytopenia which is due to:

Decreased production of plateletswhich caused by:Dehydration, Vitamin B_{12} or folic acid deficiency, systemic viral or bacterial infection, Leukemia, myelodysplastic syndrome or aplastic anemia, Decreased production of thrombopoietin by the liver in liver failure and Hereditary syndromes.

increased destruction of plateletsin cases like:pregnancy, Bacteremia, Idiopathic thrombocytopenic purpura, Thrombotic thrombocytopenic purpura, Disseminated intravascular coagulation, hypersplenism andHIV-associated thrombocytopenia.

Medication-induced:Directmyelosuppression asValproic acid , Interferon and chemotherapy drugs. (Mayo Clinic.2015, March 31). (Platelets free Encyclopedia).

1.2.2.3.4-Elevated platelet count(thrombocytosis): Which is either caused by bone marrow disorder (essential thrombocythemia), in which bone marrow over produces the cells that form platelets (megakaryocytes).

Or reactive thrombocytosis which caused by: Acute bleeding and blood loss, Allergic reactions, Infections, Hemolytic anemia, Inflammation, spleenectomy , Pancreatitis, Cancer and certain blood diseases or autoimmune disorders such as rheumatoid arthritis and connective tissue disorders and some medications like, Epinephrine, Tretinoin and Vincristine. (Platelets free Encyclopedia)(Mayo Clinic, 2012. Sept. 25).

1.3- Rationale

One study has been conducted by University ofUAE and was published in 2011 which aboutErythrocyte reference values in Emirati people with and without α^{+} thalassemia thathaveexamined 1079 citizens of UAE population and exclude abnormal 183 subjects.(Denis, 2011).

Furthermore, determination of reference range of healthy people is clinically important in terms of various complete blood count parameters. For example, haemoglobin concentration which is an important clinical measurement used in decisionsregarding clinical diagnosis, treatment and public health interventions for anaemia.Haemoglobin and haematocrit have been used routinely in the diagnosis of anaemia and polycythaemia. White blood cells and platelet count have proved helpful in the assessment of sepsis and haemostatic status respectively.(Denis, 2011).

Denic et al showed that the erythrocyte reference values for phenotype-derived normal homozygotes in Emiratis closely overlapped with those for Caucasians and normal homozygotes defined by genotyping. Haematological values are also frequently determined in the diagnostic purposes in suspected infections and in bleeding disorders.

It is now widely accepted that there are no universal or international standard haematological parameters and all reference values are affected to some extent by factors such as age, race, diet, drug intake, method employed for determination etc. It is thus important that standard reference values of local population should be established. However, haematological reference values which are in use in UAE are derived from studies done on Caucasoid populations and to the best of our knowledge, there is no reference value of haematological parameters available in UAE.

The objective of this study wasto establish red cell reference standards for Emirati population by phenotyping and to validate them through comparison with the results of other studies. (Denis, 2011).

1.4- OBJECTIVES:

1.4.1- General Objectives:

The general objective of this study is to establish native reference hematological ranges in the UAE, the thing that may help the health care providers to provide a better health care and more precise disease diagnosis.

1.4.2-Specific Objectives:

- To determine the normal count of RBCs and their indices, WBCs and Platelets in UAE Population.
- To find out factor(s)that causes abnormal blood cells count.
- To make comparison between UAE reference range and other nationals reference ranges.

MATERIALS AND METHODS

2.1- Study design:

This is a qualitative study in which 365 apparently healthy national subjects were included. Subjects were divided according to their ages to four age groups as the followings table.

Table (2.1): participant according to age groups

Age	Male female		Total
5-7 years old	44	30	74
8-12 years old	34	31	65
13-18 years old	40	27	67
>18	81	78	159
Total	191	174	365

2.2- study population:

Normal healthyEmirati in Abu Dhabi and its surrounding areas in United Arab Emirates.

2.3- Sample collection:

Samples and data were collected in the period from October 20th to November31st, 2014 from:

1- Zayed military hospital
2- Al-Noor hospital
3- Al-Ain hospital

Males and Females > 18 years old who had participated in this study in zayed military hospital were asked to sign consent form (Questioner-1), which contain information about the purpose and the study procedure. Then they answered

thequestioner that was designed to reveal the nutritional and the heath status of participants. (Questioner-2).

Allparticipants were allowed obtained their CBC results as beneficial aspects of participating in this study.

In otherhealth institute (al-Noor and al-Ain hospitals), the permission for using the samples results for the study purpose was obtained from the head supervisor of their laboratories

2.4-Laboratory requirements

From each subject 2.5ml of venous blood sample were collected in an EDTAanticoagulated tube using phlebotomy kits which include:

1- EDTA vacutainer tube.
2- Tube holder.
3- Gloves.
4- 1 gauge needle
5- Tourniquet.
6- Alcohol swab.
7- Dry cotton.
8- Band aid.

A complete blood count test (CBC) forall obtained samples was analyzed, in the same day of collection or kept at 4ºCfor analyses in the next day, by automated blood counter machines which measure the following parameters. (Abdulla, 2002), (Bain, 2006), (Myoclinic staff, 2013).

1- White blood cells(WBC).
2- Red blood cells (RBC).
3- Hemoglobin (Hb).
4- Hematocrit (HCT)
5- Mean corpuscular volume (MCV)

6- Mean corpuscular hemoglobin(MCH)
7- Mean corpuscular hemoglobin concentration(MCHC)
8- Platelets(PLT)

And also blood films were prepared and examined for cell size, shape, hemoglobin distribution, leukocyte deferential, and inclusion bodies.The films were examined by X10 of eye lens for staining quality and X40 and X100 for blood cells differentiation

The following full automated cell analyzers (Sysmex) were used:

1- XE-2100
2- XP-300
3- Kx-21

Low, normal and high controls were run daily on all automated cell analyzers.

These machines are fully automated cell analyzer, which are designed to measure more than 20 parameters using a whole blood. They
Use the following reagents for the complete blood count:

1- Normal saline(diluents)
2- Hemolysingreagent (lyses RBCs to allow measuring the hemoglobin level).

2.5- Principle of cell counter

These cell analyzers use the electronic impedance principle in counting. When acell drawn into a constant current, flowing from an electrode, the electrical conductivity changes. This generates an equivalent voltage pulse. The amplitude of the pulse is directly proportional to the volume of the represented cell (MCV). The number of pulses corresponds to the number of cells detected (WBC, RBC and PLT).

The hemoglobin level is measured by the cyanmethemoglobin method. When the cyanmethemoglobinreagent (potassium ferricyanide, sodium bicarbonate and potassium cyanide) is added to the blood sample it will lyse the RBCs forming a colored compound that its intensity is proportional to the amount of hemoglobin present.(Bain, 2006), (Burnett, 2005).

The RBC indices the HCT, MCH, and MHCH are calculated by the machine using the following formulas.(Theml, 2004)

HCT = (RBCs×10^{12}/L*****MCV) /10(%)

MCH = (Hb/RBCs×10^{12} /L) ×10 (pg)

MCHC =Hb/HCT (gm/dl).

2.6- Statistical Analysis:

The data obtained through the study were entered on the computer and analyzed by SPSS program to calculate the mean, standard deviation and P-Value by t- test and one way anova.The mean and standard deviation were determined for each age group separately. The t-test is done to make comparison between any two groups. **P<0.05** was considered statistically significant.(Social science statistics website)
The reference range is determined by calculating the mean (average) plus and minus two standard deviation.Then the normal range is calculated using the formula:

(*Lower range:*mean- (2×SD)------ *higher range:*mean+ (2×SD)).

Statistically this normal range of this analyte should encamp 95% of the normal population.(Lewis, 2011), (Turgeon, 2012).

Results:

The value of WBCs, RBCs, Hemoglobin, HCT, MCV, MCH, MCHC and PLT for the deferent age groups is presented in the following tables:

Table (3.1): 5-7 years old male

	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	7.5	4.68	11.9	35.3	76.3	25.8	33.6	262.3
Range	**3.6-11.4**	**4.1-5.3**	**10.4-13.5**	**31.1-39.7**	**66.3-86.2**	**22 -29.6**	**31.6-35.6**	**168-357**
SD	1.95	0.29	0.78	2.15	5.0	1.9	1.0	47.35

Table (3.2):8-12 year old males

	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	7.2	4.8	12.2	36.9	76.8	25.3	33	248.1
Range	**3.6-10.8**	**4.1-5.5**	**10-14**	**31-42.5**	**62.1-92.8**	**19.9-30.9**	**30.9-35.1**	**139-361**
SD	1.8	0.36	1.02	2.78	7.68	2.75	1.11	55.7

Table (3.3): **13-18 years old Males**

	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	7.5	5.3	13.4	40.1	76.2	25.4	33.2	227.6
Range	**2.4-12.6**	**4.1-6.5**	**10-16.7**	**31.8-48.5**	**55.9-96.4**	**17.3-33.4**	**30.2-36.3**	**157-298**
SD	2.57	0.61	1.67	4.17	10.1	4.01	11.5	35.2

Table (3.4):> 18 years old males

	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	7.3	5.4	14.5	42.4	78.7	26.9	34.1	226
Range	**2.9-11.7**	**4.3-6.6**	**12.1-16.8**	**36.8-48.1**	**61.3-96**	**19.9-33.8**	**31.9-36.2**	**121-331**
SD	2.19	0.57	1.19	2.84	8.67	3.47	1.04	52.46

Table (3.5): 5-7 years old female

	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	7.5	4.63	11.9	35.2	75.7	25.5	33.8	259.7
Range	**3.9-11.1**	**3.9-5.36**	**10.4-13.5**	**31.6-38.8**	**65.9-85.5**	**21.5 -29.5**	**31.8-35.8**	**169-350**
SD	1.8	0.37	0.78	1.8	4.9	2	1.0	46.35

Table (3.6):8-12 years old females

	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	7.2	4.9	12.2	36.9	75.6	25.1	33.1	244
Range	**3.9-10.5**	**4-5.8**	**10.3-14**	**32.1-41.6**	**59.7-91.6**	**18.9-31.1**	**31.1-35.2**	**150-339**
SD	1.6	0.5	0.9	2.4	8	3	1	47.1

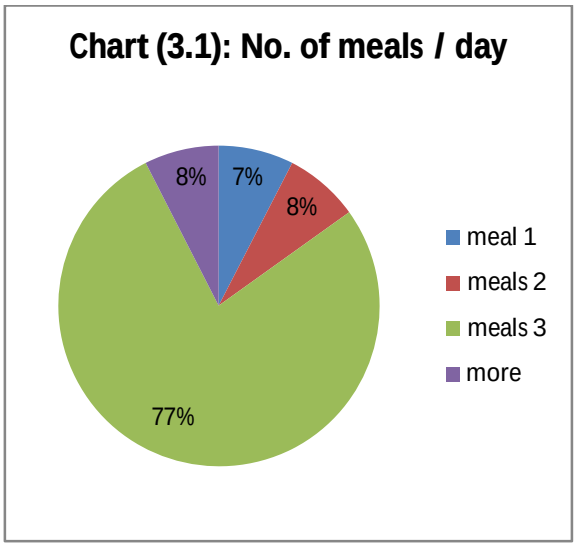
Table (3.7):13-18 years old females

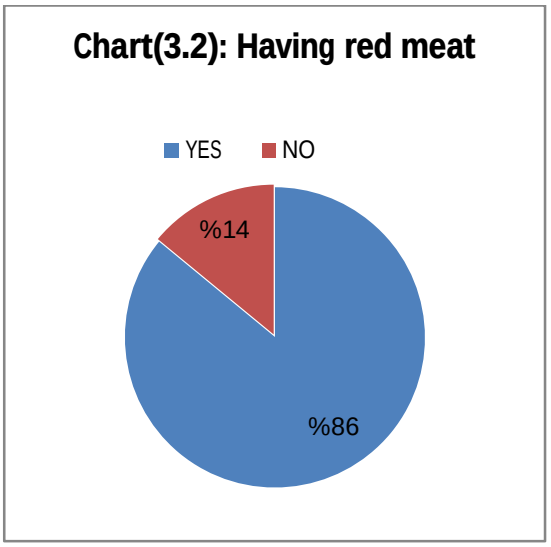
	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	7.3	4.9	11.8	35.3	74.2	24.1	32.5	243
Range	**3.3-11.3**	**3.6-6.1**	**9.1-14.5**	**21.9-48.7**	**56.9-91.6**	**17.9-30.3**	**30.1-34.9**	**107-379**
SD	2	0.6	1.4	6.7	8.7	3.1	1.2	67.8

Table (3.8):> 18 years old females

	WBC	RBC	Hb	HCT	MCV	MCH	MCHC	PLT
Mean	6.6	4.6	12.1	35.9	79.2	26.7	33.9	233.7
Range	**2.8-10.5**	**3.8-5.4**	**9.4-14.8**	**28.7-43.1**	**63.3-95**	**20.4-33.1**	**30.5-37.2**	**137-330**
SD	1.93	0.4	1.35	3.58	7.93	3.17	1.67	48.3

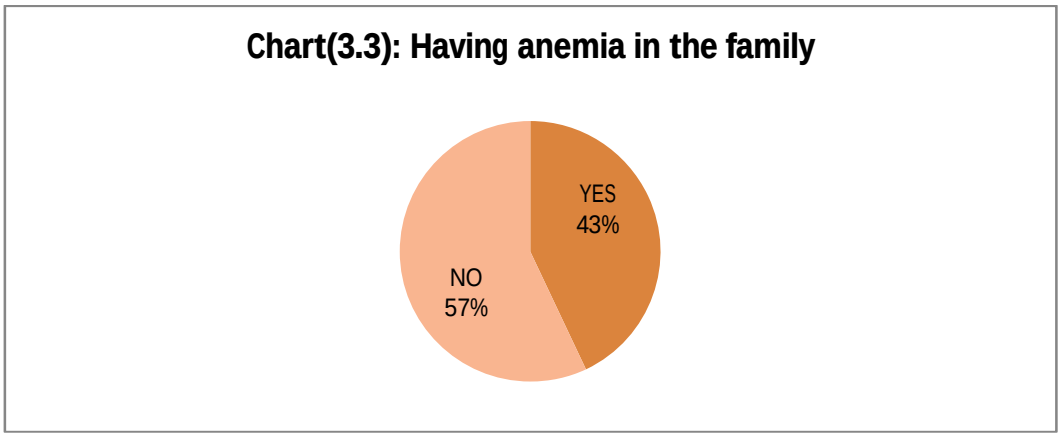
The questioner which was conducted among participant >18 years old shows that 86% of them have three or more meals per a day and they eat red meat frequently which indicate a good nutritional status. The other 14% were vegetarian and they eat 1-2 meals per a day. (Charts 3.1 and 3.2).



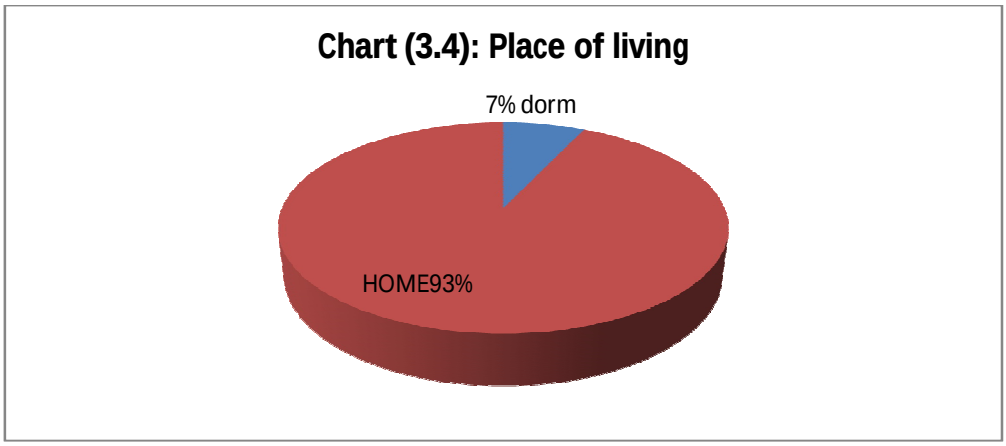


Concerning the health status of the participants 93% of them were not complaining of any sickness and they were not on any medication. The other 7% were complaining of some chronic infections or anemia, they were excluded from the study.

The study shows that 57% of participants did not have any anemic history in the family, while the other 43% having at least one of the family members with anemia. (Chart 3.3) The most type of anemia was iron deficiency anemia.



In this study 93% of female participant live at home while the other 7% live in the dorm. Living at dorm most of the times associated with bad nutritional habits as participant say.Chart (3.4).



Discussion, conclusions and Recommendations

4.1- Discussion

The results obtained through the study show an expected pattern, though some interesting exceptions are worth discussing.

The age group from (0-4) years old was not included in this study, because of some difficulties obtaining participants at such young age.

The age group (5-7) yearsfor both males and females, which mentioned in tables (1 and 6), showed a closely hematological parameters.

The **WBCs** count among the different age groups remained more or less similar and the difference between males and females was not significant except little increase in males>18.

The **RBCs**count showed a slight fluctuation with age except the significant increase in 13-18 and >18 years old males only.

A comparison withincluded studies showed that the study result of Saudi Arabia (KSA), Europe and North America agrees with our study in term of RBCs and WBCs by the same age groups,except the age group (5-7) and (8-12) years old showed less WBCs count .Also WBCs count for men in KSA appear the lowest.(6,335 ± 1759),(Abdulla, 2002)

In other hand;the normal WBCs count for adult UAE population is higher than that in Sudan. RBCscount for UAE males are little more than Sudanese males with wider upper limit, but similar between females.

The **hematocrit** level was almost fluctuation, around 33%, in all female age groups. While in males showed increase with age to reach the highest in age group >18 years old. This increase can be due to physiological changes or due to smoking which cause a decrease in plasma volume and this leads to increase in HCT level.

The KSAhematocritresults is higher than our by 2-4% in included age groups. On the other hand the Europe and North America results showed higher HCT results in all age groups.

The hemoglobin level showed a slight but not significant increase with age in males except in males over 18 years old. This increase might be due to physiological changes, or due to other factors such as smoking which tend to increase the carboxyhemoglobin level in blood.

In females the hemoglobin level shows slight changes with age, but it was significantly lower than that of males in age groups of (13-18) and (> 18) years old. This decrease in the hemoglobin level is due to the hormonal influence on haemopoisis and the menstrual blood loss.Althoughconsidering the latest factor as a significant factor is not clear, because a loss of up to 100 ml of blood with each period does not appear to cause a fall inthe hemoglobin level although it results in lower levels of serum iron. And also Samples were not collected from females during menstruation expecting that may affect the CBC result.

A comparisoncarried out between our hemoglobin level and others, showed that Hemoglobin level average in this study was lower than that in KSA (included age groups), Europe and North America by about 2,1g/lrespectively.

The **MCV** results show slight changes between age groups, except the significant increase in >18 years old males and females. The MCV level in the UAE was lower than that in the KSA, Europe and North America.

This decrease in our Hb and MCV results compared to KSA, Europe and North America results may be due to high prevalence of hereditary anemia such as sickle cell anemia, α and β-thalasemia and glucose-6-phosphate dehydrogenase deficiency (G-6-PD) and also to the prevalence of acquired anemia such as iron deficiency anemia in the UAE especially among school age children. And these anemias were not screened in the participant of this study.(Campbell, 2003)

The **MCH** and **MCHC** levels show insignificantly increase with age to reach the peak in >18 years old males and females. The Europe, North America and KSA results show higher MCH but similar MCHC results.

Platelets count shows a constant insignificant decrease in count with age. In addition to that female platelets count in age group (13-18) and >18 shows slightly higher than that in males in the same age groups.

We observes that Platelets count high in female than male , that is conformed to the National Centre for Biotechnology Information, U.S. National Library of Medicine that. (The platelet count of healthy males was compared to that of healthy females; a higher platelet count in women was confirmed).(Haematol, 1985)

With a comparison to other populations, UAEpopulation has lower plateletscount thanEurope, American and Sudanese.(Lewis, 2011), (Osman, 2013).

Similar studies conducted in Nordic counties and china which include adults only, the results were closed in theRBCs and MCHC levels, but higher in the Hb, HCT, MCV and MCH and lower in WBCs resultscompared to this study.(Cong, 2004), (Nordin, 2004).

In the UAE 40% of population suffers from blood disorders. The prevalence of hemoglobinopathies is among the highest in the region and thalassemia trait is the most prevalence type of them.(Khamis, 2013).

The iron deficiency anemia also has a high prevalence in the UAE especially among children.This type of anemia is more likely to be due to the consumption of highly refined foods, lower intake of iron rich food, presence of parasitic infections and high consumption of junk foods such as soft drinks and chocolate which are high caloric content and low nutritive value.

The estimated abnormalities forUAE children were as follows: anemia 36.1%; iron deficiency anemia 9.9%; glucose-6-phosphate dehydrogenase (G6PD) deficiency 9.1%; sickle cell trait 4.6%; and beta thalassemia 8.7%. There was likely to be a high prevalence of alpha thalassemia.(Campbell, 2003)

4.2- Conclusion

Normal ranges of most analytes vary widely in deferent parts of the world. These differences are due to several factors such as sex, age, race, genetics, body built and social, nutritional and environmental factors.

This study has attempted to establish the hematological normal reference ranges in the UAE.

The study results showan expected pattern in all analytes except the Hb and MCV results. They were significantly lower in all age groups in our study population which might be due to the high prevalence of hereditary and acquired anemia in the UAE.

4.3- Recommendations

I recommend this research to be redone on a much larger sample that better represents the entire the population of the UAE and covers all age groups. I also recommend that all participants be screened for all types of anemia before including their results in the research.

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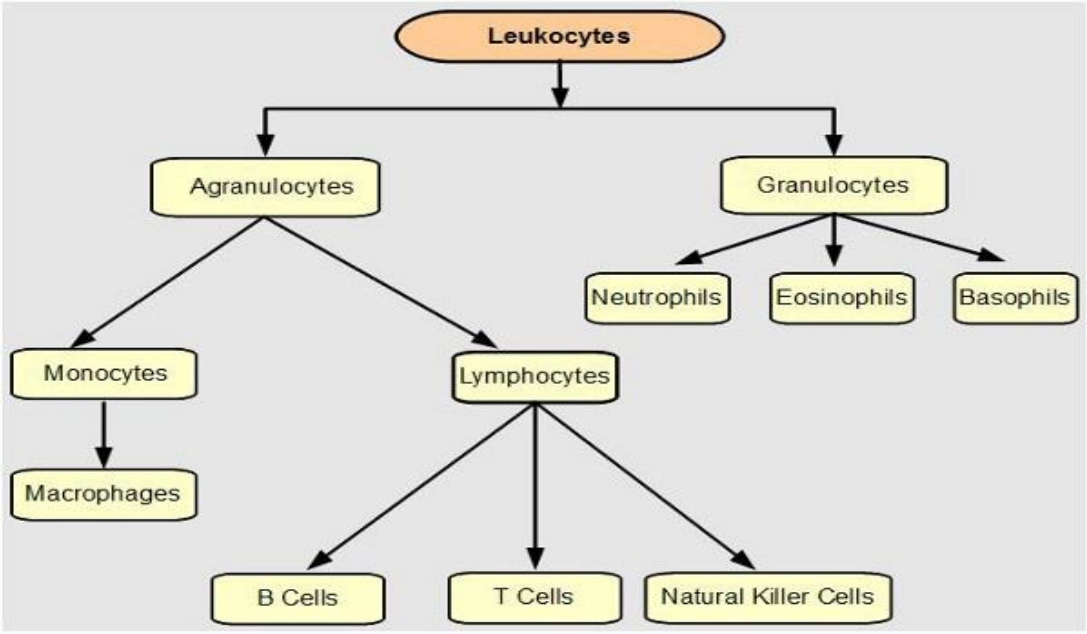
Appendix A–Types of WBCs



Appendix-B: Red Blood Cells Indices:

Parameter	Definition	Units	Formula	Example
Mean cell volume (MCV)	Average volume of the red blood cell (RBC)	Femtoliters (fL) or 10^{-15}Liter	$MCV = \frac{\text{Hematocrit(\%)} \times 10}{\text{RBC} (\times 10^{12}/\text{L})}$	$MCV = \frac{42 \times 10}{4.2} = 100$ fL
Mean cell hemoglobin (MCH)	Average weight of hemoglobin (Hb) in the RBC	Picograms (pg) or 10^{-12} grams	$MCH = \frac{\text{Hb (g/dL)} \times 10}{\text{RBC} (\times 10^{12}/\text{L})}$	$MCH = \frac{12.5 \times 10}{4.1} = 30.5$
Mean cell hemoglobin concentration (MCHC)	Average concentration of Hb in the RBC volume	Grams/deciliter (g/dL)	$MCHC = \frac{\text{Hb (g/dL)} \times 100}{\text{Hematocrit (\%)}}$	$MCHC = \frac{12.5 \times 100}{37} = 34$

Appendix C: Normal Values forRBCs Indices

Normal adult red cell values

	Male	Female
Haemoglobin* (g/dl)	13.5–17.5	11.5–15.5
Haematocrit (PCV) (%)	40–52	36–48
Red cell count ($\times 10^{12}$/l)	4.5–6.5	3.9–5.6
Mean cell haemoglobin (pg)	27–34	
Mean cell volume (fl)	80–95	
Mean cell haemoglobin concentration (g/dl)	30–35	
Reticulocyte count ($\times 10^{9}$/l)	25–125	

*In children normal haemoglobin values are: newborn, 15.0–21.0 g/dl; 3 months, 9.5–12.5 g/dl; 1 year to puberty, 11.0–13.5 g/dl.
PCV, packed cell volume.

Appendix D

RBCs INDICES FROM EARLY CHILDHOODTHROUGH ADOLESCENCE IN SAUDIS

TABLE 2. *Hematological parameters in 1-15-year-old Saudi children.*

Age (years)	Sex	RBC x10^{12}/L	WBC x10^{9}/L	Hb g/dL	PCV (%)
Up to 1	M	4.8±0.52	7.2±1.2	12.3±1.2	36.0±2.3
	F	4.8±0.41	6.7±1.1	13.1±1.0	38.0±2.6
>1-2	M	4.8±0.39	8.7±2.2	11.3±1.0	34.0±2.8
	F	4.9±0.45	8.5±1.9	11.7±1.0	36.0±2.4
>2-3	M	4.8±0.32	8.6±2.3	12.2±1.0	36.0±3.1
	F	4.9±0.62	8.0±2.4	12.2±1.3	37.0±3.4
>3-4	M	4.8±0.36	7.4±1.6	12.0±1.1	36.0±2.5
	F	4.8±0.43	7.6±1.8	12.7±0.9	38.0±2.5
>4-5	M	4.7±0.30	7.5±2.2	12.5±1.1	37.0±2.7
	F	4.69±0.3	7.5±2.2	12.6±1.1	37.0±2.8
>5-6	M	4.9±0.47	7.7±2.2	12.9±1.1	38.0±2.9
	F	4.7±0.55	7.5±2.2	12.9±1.17	38.0±3.7
>6-7	M	4.8±0.49	7.8±2.2	12.9±1.2	38.0±2.9
	F	4.7±0.4	7.6±2.2	13.1±0.98	38.0±3.3
>7-8	M	4.9±0.28	7.0±2.0	13.5±0.90	39.0±3.4
	F	4.8±0.5	7.5±2.2	13.1±1.8	38.0±3.5
>8-9	M	4.9±0.28	7.0±2.0	13.5±0.90	39.0±2.6
	F	4.8±0.5	7.5±2.8	13.1±1.8	39.0±3.8
>9-10	M	4.9±0.37	6.7±2.2	13.6±1.9	40.0±3.7
	F	4.8±0.39	7.0±1.9	13.0±1.7	38.3±3.5
>10-11	M	4.8±0.44	6.5±2.3	13.3±1.9	39.5±3.5
	F	4.8±0.44	6.5±2.2	13.5±0.79	39.7±2.2
>11-12	M	4.9±0.43	6.5±2.1	13.5±1.3	39.0±3.1
	F	4.9±0.38	6.7±1.75	13.4±1.28	39.0±3.3
>12-13	M	4.86±0.45	6.8±1.9	13.5±0.84	39.8±2.6
	F	4.8±0.46	6.9±2.8	13.7±1.25	40.3±3.3
>13-14	M	5.1±0.52	6.5±1.7	14.1±1.4	41.4±3.0
	F	4.9±0.41	7.0±2.0	13.8±1.3	40.7±3.3
>14-15	M	5.1±0.26	7.9±2.1	14.2±1.1	41.8±2.8
	F	4.9±0.59	7.14±2.1	13.8±1.2	39.4±3.0

Appendix- E

RBCs INDICES FROM EARLY CHILDHOODTHROUGH ADOLESCENCE IN SAUDIS

TABLE 3. *Red cell indices in 1-15- year-old Saudi children.*

Age (years)	Sex	MCV (fl)	MCH (pg)	MCHC (g/dL)
Up to 1	M	75.0±4.9	26.0±3.0	34.0±1.5
	F	78.0±7.3	26.9±2.7	34.0±0.7
>1-2	M	72.0±6.8	24.0±2.9	33.0±1.3
	F	72.0±7.8	24.0±3.1	33.0±1.2
>2-3	M	75.0±5.0	26.0±3.2	33.0±2.2
	F	75.0±7.7	25.0±3.0	33.0±1.2
>3-4	M	74.0±6.1	25.0±2.5	34.0±1.4
	F	78.0±4.9	26.0±1.8	34.0±1.0
>4-5	M	78.0±4.6	27.0±2.5	33.0±1.2
	F	79.0±5.7	27.0±2.8	34.0±1.0
>5-6	M	79.0±4.9	27.0±2.1	34.0±1.2
	F	80.0±4.9	27.0±2.0	34.0±1.3
>6-7	M	78.0±9.0	27.0±2.8	34.0±1.3
	F	81.0±4.0	27.0±2.1	34.0±2.1
>7-8	M	79.0±7.7	27.0±1.8	33.9±1.8
	F	79.0±6.5	27.0±2.7	34.0±1.2
>8-9	M	80.0±5.1	27.0±1.8	34.0±1.3
	F	80.0±5.2	27.0±3.1	34.0±1.3
>9-10	M	81.0±5.1	27.6±2.3	34.0±1.2
	F	79.6±6.1	27.0±2.3	34.0±1.3
>10-11	M	80.4±8.1	27.6±2.1	34.1±1.3
	F	80.8±4.4	27.5±1.8	34.0±1.0
>11-12	M	80.3±5.1	27.3±2.2	34.0±1.6
	F	80.0±6.3	27.0±2.5	34.0±1.5
>12-13	M	81.8±5.6	27.6±2.1	33.9±1.3
	F	81.0±5.4	27.6±2.0	33.9±1.1
>13-14	M	80.0±5.9	27.0±2.3	34.0±1.3
	F	83.6±4.7	28.6±2.3	34.0±1.2
>14-15	M	81.0±6.4	27.8±1.8	34.0±1.12
	F	81.0±6.4	27.1±2.9	33.6±1.8

Appendix-F (Europe and North America reference ranges for blood cells-adults)

Red blood cell count	
Men	$5.0 \pm 0.5 \times 10^{12}$/l
Women	$4.3 \pm 0.5 \times 10^{12}$/l
Haemoglobin concentration[a]	
Men	150 ± 20 g/l
Women	135 ± 15 g/l
Packed cell volume (PCV) or Haematocrit (Hct)	
Men	0.45 ± 0.05 (l/l)
Women	0.41 ± 0.05 (l/l)
Mean cell volume (MCV)	
Men and women	92 ± 9 fl
Mean cell haemoglobin (MCH)	
Men and women	29.5 ± 2.5 pg
Mean cell haemoglobin concentration (MCHC)	
Men and women	330 ± 15 g/l
Red cell distribution width (RDW)	
As coefficient of variation (CV)	12.8 ± 1.2%
As standard deviation (SD)	42.5 ± 3.5 fl
Red cell diameter (mean values)	
Dry films	6.7–7.7 μm
Red cell density	1092–1100 g/l
Reticulocyte count	$50–100 \times 10^9$/l (0.5–2.5%)
White blood cell count	$4.0–10.0 \times 10^9$/l
Differential white cell count	
Neutrophils	$2.0–7.0 \times 10^9$/l (40–80%)
Lymphocytes	$1.0–3.0 \times 10^9$/l (20–40%)
Monocytes	$0.2–1.0 \times 10^9$/l (2–10%)
Eosinophils	$0.02–0.5 \times 10^9$/l (1–6%)
Basophils	$0.02–0.1 \times 10^9$/l (<1–2%)
Lymphocyte subsets (approximations from ranges in published data)	
CD3	$0.6–2.5 \times 10^9$/l (60–85%)
CD4	$0.4–1.5 \times 10^9$/l (30–50%)
CD8	$0.2–1.1 \times 10^9$/l (10–35%)
CD4/CD8 ratio	0.7–3.5
Platelet count	$280 \pm 130 \times 10^9$/l

Appendix G: (Europe and North America reference ranges for blood cells, 1-12yrs)

Table 2.3 Haematological values for normal children (amalgamation of data derived from various sources; expressed as mean ± 2SD or 95% range)

	1 Year	2–6 Years	6–12 Years
Red cell count ($\times 10^{12}$/l)	4.5 ± 0.6	4.6 ± 0.6	4.6 ± 0.6
Haemoglobin concentration (g/l)	126 ± 15	125 ± 15	135 ± 20
Haematocrit (Hct) or packed cell volume (PCV) (l/l)	0.34 ± 0.04	0.37 ± 0.03	0.40 ± 0.05
Mean cell volume (MCV) (fl)	78 ± 6	81 ± 6	86 ± 9
Mean cell haemoglobin (MCH) (pg)	27 ± 2	27 ± 3	29 ± 4
Mean cell haemoglobin concentration (MCHC) (g/l)	340 ± 20	340 ± 30	340 ± 30
Reticulocytes ($\times 10^9$/l)	30–100	30–100	30–100
White cell count ($\times 10^9$/l)	11 ± 5	10 ± 5	9 ± 4
Neutrophils ($\times 10^9$/l)	1–7	1.5–8	2–8
Lymphocytes ($\times 10^9$/l)	3.5–11	6–9	1–5
Monocytes ($\times 10^9$/l)	0.2–1.0	0.2–1.0	0.2–1.0
Eosinophils ($\times 10^9$/l)	0.1–1.0	0.1–1.0	0.1–1.0
Lymphocyte subsets ($\times 10^9$/l)[a]			
CD3	1.5–5.4	1.6–4.2	0.9–2.5
CD4	1.0–3.6	0.9–2.9	0.5–1.5
CD8	0.6–2.2	0.6–2.0	0.4–1.2
CD4/CD8 ratio	1.0–3.0	0.9–2.7	1.0–3.0
Platelets ($\times 10^9$/l)	200–550	200–490	170–450

Questioner-1

The informed consent

Consent to act as a participant in the research:
(The reference hematological ranges in the UAE within nationals)
I am medical laboratory technology student at Sudan Universityof science and technology, and I'm conducting a research study as part of the requirement for the master degree in MLT.

This study will be done to provide the health care institution with this study that may improve the medical care provided for the society and help in diagnosis.

This study will involve national participants from four age groups of both genders. From each participant a peripheral blood sample will be collected in EDTA tube to measure the complete blood count (CBC) by an automated machine.

The participant in this study should:
A -be completely healthy.
B -Non smoker.
C -Don’t suffers from any kind of anemia (iron deficiency anemia, sickle cell anemia or thalasemia).
D -Females shouldn't have the menstrual period during the test and should not be pregnant.

Participants can take their CBC result and acopy of the study can be obtained after the research accomplished by mailing me at this e-mail address (os_thawabi@yahoo.com or thawabi@ymail.com).

Participant name:
Age:
Date:
Signature:

Questioner-2

Questioner for the research project

"The normal hematological range in the UAE among nationals"

This questioner will take five minutes to be answered.

**Please attempt all questions.*

1-How many meals you eat per day?

1-……2-…… 3-…… more……..

2-Do you eat red meat?

Yes …….. No ……..

3-Are you complaining of any disease?

Yes ……. No ……

If yes identify please …….

4-Are you on any medication?

Yes ……. No ……

If yes identify please …….

5-Do any of your family have anemia?

Yes ……. No ……

If yes identify please …….

6-Where are you living?

At home…… In the dorm

How many days the menstrual periodstays?

……..

Thank you for participation