World Health Organization

Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity

WHO/NMH/NHD/MNM/11.1

VMNIS | Vitamin and Mineral Nutrition Information System

Inside

Background

Anaemia is a condition in which the number of red blood cells (and consequently their oxygen-carrying capacity) is insufficient to meet the body's physiologic needs. Specific physiologic needs vary with a person's age, gender, residential elevation above sea level (altitude), smoking behaviour, and different stages of pregnancy. Iron deficiency is thought to be the most common cause of anaemia globally, but other nutritional deficiencies (including folate, vitamin B_{12} and vitamin A), acute and chronic inflammation, parasitic infections, and inherited or acquired disorders that affect haemoglobin synthesis, red blood cell production or red blood cell survival, can all cause anaemia. Haemoglobin concentration alone cannot be used to diagnose iron deficiency. However, the concentration of haemoglobin should be measured, even though not all anaemia is caused by iron deficiency. The prevalence of anaemia is an important health indicator and when it is used with other measurements of iron status the haemoglobin concentration can provide information about the severity of iron deficiency (*1*).

Scope and purpose

This document aims to provide users of the Vitamin and Mineral Nutrition Information System (VMNIS) with information about the use of haemoglobin concentration for diagnosing anaemia. It is a compilation of current World Health Organization (WHO) recommendations on the topic and summarizes the cut-offs for defining anaemia and its severity at the population level, as well as the chronology of their establishment.

The use of the cut-off points derived from the referenced publications permits the identification of populations at greatest risk of anaemia and priority areas for action, especially when resources are limited. They also facilitate the monitoring and assessment of progress towards international goals of preventing and controlling iron deficiency and further provide the basis for advocacy for the prevention of anaemia.

Description of technical consultation

This document compiles current WHO guidelines from five documents:

Nutritional anaemias (*2*), is a report of a WHO Scientific Group that consisted of an international group of experts convened in Geneva, Switzerland from 13-17 March 1967. The consultation was called three years after the start of a worldwide multi-country collaborative study in India, Israel, Mexico, Poland, South Africa, the United Kingdom, the United States of America, and Venezuela. The study investigated iron metabolism in pregnancy as well as the role of hookworm in anaemia during pregnancy, and further tested the procedures for examining blood and serum. The 1967 consultation reviewed overall progress of these studies and also discussed nutritional requirements of iron, folate, and vitamin B_{12}.

Preventing and controlling anaemia through primary health care (*3*) was published after a May 1987 meeting of the International Nutritional Anaemia Consultative Group (INACG) in Quito, Ecuador. This publication aims to help health administrators and programme managers to develop and implement suitable strategies for preventing and controlling iron deficiency anaemia. It also considers some of the practical aspects of integrating primary care at various levels of organization learnt from the JNSP (WHO/UNICEF Joint Nutrition Support Programme), which was active in 18 countries at that time.

The management of nutrition in major emergencies (*4*) was published by WHO in response to the World Declaration and Plan for Action in Nutrition (*5*) that urged governments to provide sustainable assistance to refugees, displaced and war-affected populations where high rates of malnutrition and micronutrient deficiencies occur.

Iron deficiency anaemia: assessment, prevention and control, a guide for programme managers (*6*), a document published in 2001, is mainly based on a consultation organized by WHO, UNICEF, and the United Nations University (UNU) held in Geneva, Switzerland, 6-10 December 1993. The purpose of this consultation was to provide scientists and national authorities a timely and authoritative review of iron deficiency anaemia, and also to help managers of national micronutrient malnutrition prevention and control programmes to identify effective measures for fighting iron deficiency anaemia. The conclusions of the consultation were complemented with additional scientific literature that appeared before 2000.

Assessing the iron status of populations (*1*) is the report of a joint WHO and US Centers for Disease Control and Prevention (CDC) Technical Consultation held in Geneva, Switzerland, 6-8 April 2004, with the participation of 34 experts. With the ultimate goal of planning effective interventions to combat both iron deficiency and anaemia, the objectives of the Consultation were to review the indicators currently available to assess iron status, to select the best indicators for assessing the iron status of populations, to select the best indicators to evaluate the impact of interventions to control iron deficiency in populations, and to identify priorities for research related to assessing the iron status of populations. This Consultation was preceded by a short WHO/CDC working group meeting held in January 2004 to review the literature on indicators of iron status and to select indicators for discussion. In April 2004, the Consultation was provided with literature reviews on indicators of iron status, including red blood cell (RBC) parameters, ferritin, free erythrocyte protoporphyrin, serum and plasma iron, total iron binding capacity, transferrin saturation and serum transferrin receptor as well as a review on the interpretation of indicators of iron status during an acute phase response. These four reviews are available in the second edition, published in 2007.

Recommendations

Table 1
Haemoglobin levels to diagnose anaemia at sea level (g/l)±

Population	Non -Anaemia*	Anaemia*		
		Mild[a]	Moderate	Severe
Children 6 - 59 months of age	110 or higher	100-109	70-99	lower than 70
Children 5 - 11 years of age	115 or higher	110-114	80-109	lower than 80
Children 12 - 14 years of age	120 or higher	110-119	80-109	lower than 80
Non-pregnant women (15 years of age and above)	120 or higher	110-119	80-109	lower than 80
Pregnant women	110 or higher	100-109	70-99	lower than 70
Men (15 years of age and above)	130 or higher	110-129	80-109	lower than 80

± Adapted from references 5 and 6
* Haemoglobin in grams per litre
a "Mild" is a misnomer: iron deficiency is already advanced by the time anaemia is detected. The deficiency has consequences even when no anaemia is clinically apparent.

The anaemia cut-offs presented in Table 1 were published in 1968 by a WHO study group on nutritional anaemias (*2*), while the cut-offs defining mild, moderate and severe anaemia were first presented in the 1989 guide *Preventing and controlling anaemia through primary health care* (*3*) and then modified for pregnant women, non-pregnant women, and children less than five years of age in *The management of nutrition in major emergencies* (*4*). The overall anaemia cut-offs have been unchanged since 1968, with the exception that the original age group of children 5-14 years of age was split, and a cut-off of 5 g/l lower was applied to children 5-11 years of age to reflect findings among non-iron deficient children in the USA (*6*). Although these cut-offs were first published in the late 1960s, they have been included in numerous subsequent WHO publications (*3,4,6*) and were additionally validated by findings among participants in the Second National Health and Nutrition Examination Survey (NHANES II) who were unlikely to have iron deficiency based on a number of additional biochemical tests (*7*).

The haemoglobin cut-off of 110 g/l for pregnant women was first presented in the 1968 report along with results of the five studies mentioned previously. In healthy, iron-sufficient women, haemoglobin concentrations change dramatically during pregnancy to accommodate the increasing maternal blood volume and the iron needs of the fetus (*3*). Concentrations decline during the first trimester, reaching their lowest point in the second trimester, and begin to rise again in the third trimester. Currently, there are no WHO recommendations on the use of different haemoglobin cut-off points for anaemia by trimester, but it is recognized that during the second trimester of pregnancy, haemoglobin concentrations diminish approximately 5 g/l.

Residential elevation above sea level and smoking are known to increase haemoglobin concentrations (*6*). Consequently, the prevalence of anaemia may be underestimated in persons residing at high altitudes and among smokers if the standard anaemia cut-offs are applied. Table 2 presents the recommended adjustments to be made to the measured haemoglobin concentration among persons living at altitudes higher than 1000 metres above sea level, and Table 3 presents these adjustments for smokers. These adjustments must be made to the measured haemoglobin concentration for the anaemia cut-offs presented in Table 1 to be valid. Elevation adjustments are derived using data from the US Centers for Disease Control and Prevention's (CDC) Pediatric Nutrition Surveillance System in children living in mountainous states, while the smoking adjustments are derived from NHANES II data. Both

adjustments are additive, i.e. smokers living at higher altitudes would have two adjustments made. In addition to elevation and smoking, it has been suggested that there are small differences in the distributions of haemoglobin values among different ethnic groups (*6*), however, the data is still scarce and the use of standard cut-offs is recommended

Both the method of haemoglobin measurement and blood sample source (capillary versus venous blood) can affect the measured haemoglobin concentration. The cyanmethemoglobin and the HemoCue® system are the methods generally recommended for use in surveys to determine the population prevalence of anaemia *(6)*. In the cyanmethemoglobin method, a fixed quantity of blood is diluted with a reagent and haemoglobin concentration is determined after a fixed time interval in an accurate, well calibrated photometer. The cyanmethemoglobin measurement is the reference laboratory method for the quantitative determination of haemoglobin and is used for comparison and standardization of other methods (*6*). The HemoCue® system is based on the cyanmethemoglobin method and has been shown to be stable and durable in field settings. The source of the blood sample should also be considered when assessing haemoglobin concentrations. Some studies suggest that haemoglobin values measured in capillary samples are higher than those measured in venous samples, potentially leading to false-negative results (*6*).

The haemoglobin cut-offs presented in Table 1 are used to diagnose anaemia in individuals in a screening or clinical setting, but the public health significance of anaemia in a population can then be determined by applying the criteria shown in Table 4.

Summary development

The main bibliographic sources of this summary were five WHO publications *(1-4,6)* released between 1968 and 2005. It was considered that each of them provided inputs that helped to build the knowledge in this area. Briefly, haemoglobin cut-offs were first presented in the 1968 document *(2)* and were based on four published references (*8-11)* and one set of unpublished observations. Definitions for mild, moderate, and severe anaemia were first published in 1989 *(3)* and slightly modified in a subsequent publication on nutrition in emergencies *(4)*, which also proposes a classification to determine the public health significance of anaemia in populations. Finally, the 2001 guide for managers split the age group for children 5-14 years of age and applied a new, lower haemoglobin cut-off for children 5-11 years of age based on NHANES II data. The 2001 document additionally provided haemoglobin adjustments for altitude and smoking.

Table 2
Altitude adjustments to measured haemoglobin concentrations

Altitude (metres above sea level)	Measured haemoglobin adjustment (g/l)
< 1000	0
1000	-2
1500	-5
2000	-8
2500	-13
3000	-19
3500	-27
4000	-35
4500	-45

Table 3
Adjustments to measured haemoglobin concentrations for smokers

Smoking status	Measured haemoglobin adjustment (g/l)
Non-smoker	0
Smoker (all)	-3
½ -1 packet/day	-3
1-2 packets/day	-5
≥ 2 packets/day	-7

Plans for updating this summary

The WHO Micronutrients Unit, Department of Nutrition for Health and Development, is responsible for reviewing this document and if needed will update it by 2014, following the newly adopted *WHO Handbook for guideline development* (*12*) procedures.

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Table 4
Classification of public health significance of anaemia in populations on the basis of prevalence estimated from blood levels of haemoglobin

Category of public health significance	Prevalence of anaemia (%)
Severe	40 or higher
Moderate	20.0 – 39.9
Mild	5.0 – 19.9
Normal	4.9 or lower

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